POWER PLANT ENGINEERING

Established Over 34 Years

VOL. XXXIV CHICAGO, AUGUST 15, 1930 No. 16

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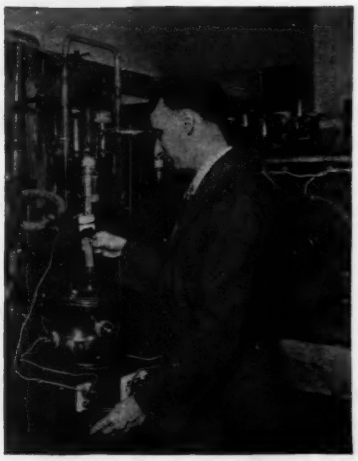
Published on the 1st and 15th of each Month by the
Technical Publishing Co., 53 West Jackson Blvd., Chicago
New York Office, 171 Madison Avenue

Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.
Copyright 1930, by Technical Publishing Co.
Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations.

Circulation of this issue 23,400



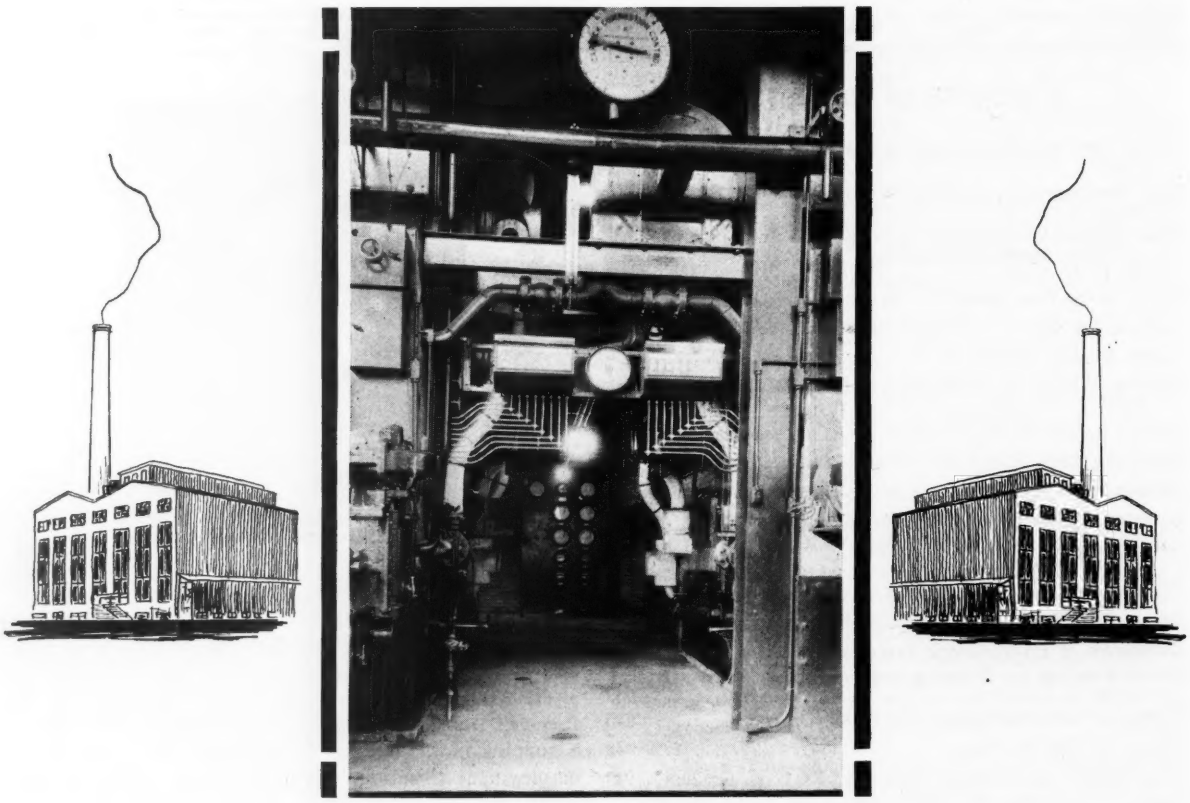
More Farm Relief

ALONG WITH the government, politicians, implement and fence manufacturers the time has come for the electric power industry to put in its oar and help the farmer. Raise more crops? Statisticians say there is a surplus now. Reduce farm labor? The present unemployment situation bids us to pause. Milk his cows, hatch and raise his chicks, churn his butter, saw his wood, grind his feed—yes indeed, but here is a new service to which nobody will object. Let's kill his bugs.

Just read this news item and the next step is clearly to set out electrical traps: "The corn borer has a smeller! This fact government scientists have discovered, with the result that they intend to lure the destructive bug away from its unwelcome home in the corn fields. Of 900 odors in corn, only five attract the borer. By placing these five away from crops, the moth will be lured to a spot where he can chew on electric wires or some other less healthy food."

Activities need not be confined to the corn borer for there are chinc bugs, grass hoppers, boll weevil, potato bugs and numerous other insects, not to omit mosquitoes, that undoubtedly have smellers keen enough to lead them to a properly baited electrical trap. Those specializing in this branch of the industry must be versed in remote control and we recommend reading Mr. Von Dannenberg's article on page 931 as a beginning. Then, too, the electric arc has possibilities as a moth exterminator which should not be overlooked. Perhaps that is why Dr. Slepian of the Westinghouse Co. is studying it so intently in the above picture but his story you will find in the Off Duty column on page 957. Whatever the process, it must be done electrically.

78 Per cent Boiler Efficiency *at the new* Barber Asphalt Plant



WHEN THE ENGINEERS and officers of the Barber Asphalt Co. at Madison, Illinois, near St. Louis, Mo., decided to replace their existing boiler plant by a new plant some two years ago, the average monthly power cost varied between $6500 and $9500. Today, with the new plant it averages from $4500 to $5000, a net saving of from $2000 to $4500 per month.

This remarkable saving is due not so much to the use of modern, efficient equipment, for there are many plants using the same equipment which do not approach the efficiencies in this plant, but more to the sound engineering principles incorporated in its design and to intelligent operation. Designed and constructed by Baumes-McDevitt Co. of St. Louis, Mo., this plant reflects the wide experience these engineers have had in the design of industrial power plants, for it is characterized by an excellence of design that would be a credit to many central stations. Design, however, is not the entire story in a case of this kind, for the advantages of good design are often set at naught by unintelligent operation. This plant, under the supervision of Wm. J. Hart, the chief engineer, maintains an average boiler efficiency of over 78 per cent, notwithstanding the fact that the boilers, built for 400-lb. pressure and 100 deg. superheat, are being operated at present at only 135-lb. With an average CO_2 content of the gases of 12½ to 13½ per cent and when operating at about 150 per cent rating, the flue gas temperature is usually around 410 to 420 deg. At 90 per cent rating it is 390 deg. It has never exceeded 500 deg.

General Features

As shown by the exterior view, the plant is housed in an attractive building of substantial construction. It is built of brick, steel and concrete and is well lighted by large windows on three sides. No windows were placed in the wall facing the rear of the boilers, as it is the intention of the management later to add a turbine room to this side of the building and this wall will then serve as a dividing wall between the boiler and turbine rooms. At the present time, the electric generating equipment consists of two Corliss engine units, located in an old engine room a short distance from the boiler house. One of these is a 150-kw. unit and the other a 250-kw. unit. The use of 100 deg. superheat in place of dry saturated steam has occasioned about 15 per cent reduction in the use of steam by the Corliss engine units and various pumping units.

The plant is provided with a fine stack on the outside of the building as shown. This is a reënforced concrete and masonry stack, 175 ft. 6 in. in height and 7 ft. inside diameter at the top. It was built by the Wiederholdt Construction Co.

A cross section of the building is shown in Fig. 2 and in Fig. 3 is a plan. These drawings show the relative location of the equipment. At present, two boilers are installed but space has been provided for a third unit later on. Coal for immediate use is stored in an overhead steel bunker, one section of which is used for ash storage.

The coal is delivered to the plant by rail and dumped into a track hopper onto an apron conveyor. The latter delivers directly into a pivoted bucket conveyor traveling a rectangular path around the boiler house and delivering coal into the overhead bunkers at the top. This same bucket conveyor is also used for handling ash as will be described.

An important feature in connection with the design of the coal handling equipment and one which we wish to emphasize is the entire enclosure of the apron conveyor and receiving hopper in a dust proof room. Delivery of coal into a track hopper is always accompanied by the production of coal dust and if the receiving equipment is not isolated from the rest of the plant, this dust will spread to all parts of the boiler house. At the Barber Asphalt plant, the receiving equipment is all located in a separated brick room fitted with steel dust-tight doors. The pivoted bucket conveyor enters this room through small openings designed so as to limit the passage of dust through them. This feature, while of apparently small importance in the design of a plant, nevertheless contributes largely to the "good housekeeping" in the plant and thus improves the morale of the operating force.

Another feature of particular interest about the coal handling arrangement is the double use of the conveyor for both coal and ash handling.

The scheme used is shown in Fig. 2. A portable belt conveyor is provided to transfer the ash from the ash hopper to the lower run of the pivoted bucket conveyors. The portable conveyor is suspended by means from a monorail and when ash is to be removed from an ash pit, it is placed in position before the ash pit door. Ash is then raked into the belt and delivered into a bucket conveyor in the center of the room. The arrangement is also shown in the photograph Fig. 4B.

This arrangement, not only "saved" the installation of an independent ash handling system, but also precluded the necessity for excavating for a deeper basement, which would have been the case had a different arrangement been employed. At the same time, this scheme has operated perfectly satisfactorily and after it was installed, required only one addition. It was found that while the ash was being raked onto the belt, the ash pit doors being open, the CO_2 content of the gases of combustion dropped considerably due to the entrance of large quantities of air. To prevent this, a damper was installed in each ash pit which "closes" the ash pit while the ash is being removed.

After its removal from the ash pit, the ash is delivered to the end section of the overhead coal bunker. Here it is stored until it can be removed from the plant. Two chutes deliver ashes either to truck or railroad car, as shown in Fig. 2. All coal and ash handling machinery with the exception of the Richardson automatic coal scales by which the coal is weighed before being delivered to the stoker hoppers from the overhead bins, is of Jeffrey manufacture.

Boilers Are Built for 400-Lb. Pressure

The two boilers which form the present installations, although operating now at only 135-lb. pressure, are built for a working pressure of 400 lb. Boilers for this pressure were selected because a turbine room will be added in the near future with turbines operating at that pressure. All piping and fittings in the present installation is temporary only. The temporary piping in this plant deserves especial mention as it is of the most approved construction, all joints being welded.

Each of the two Stirling boilers is rated at 547 hp. and is fired by an Illinois force draft chain grate stoker, 9 ft. wide by 13 ft. long with six individual wind boxes. Each stoker is driven by a Reliance 115-v. d.c. motor, mounted on the stoker casing and controlled automatically by the combustion control system.

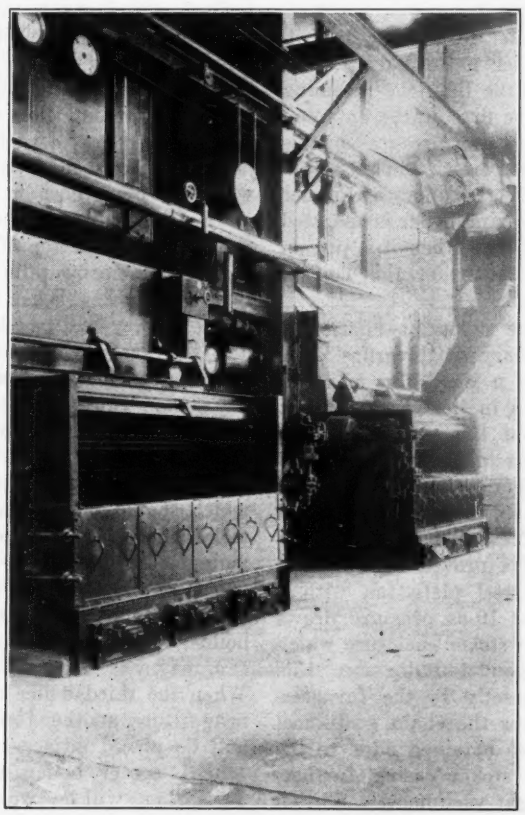


FIG. 1. STOKERS ARE ENTIRELY ENCLOSED

Forced draft is supplied by a Buffalo Forge Co. Turbo conoidal fan driven by a 10-hp., 115-v. d.c. motor. This motor also is controlled by the combustion control system. The latter is the standard Carrick system which not only regulates the amount of air supplied and the stoker speed in accordance with the load on the boiler, but also maintains a draft of from .01 to .03 in. over the fire at all times. The draft loss through the furnace at 100 per cent rating is 0.2 in. and at 200 per cent, 0.38 in.

As only one boiler is operated at a time, the control chains from the combustion control system to the stoker motor and forced draft motor

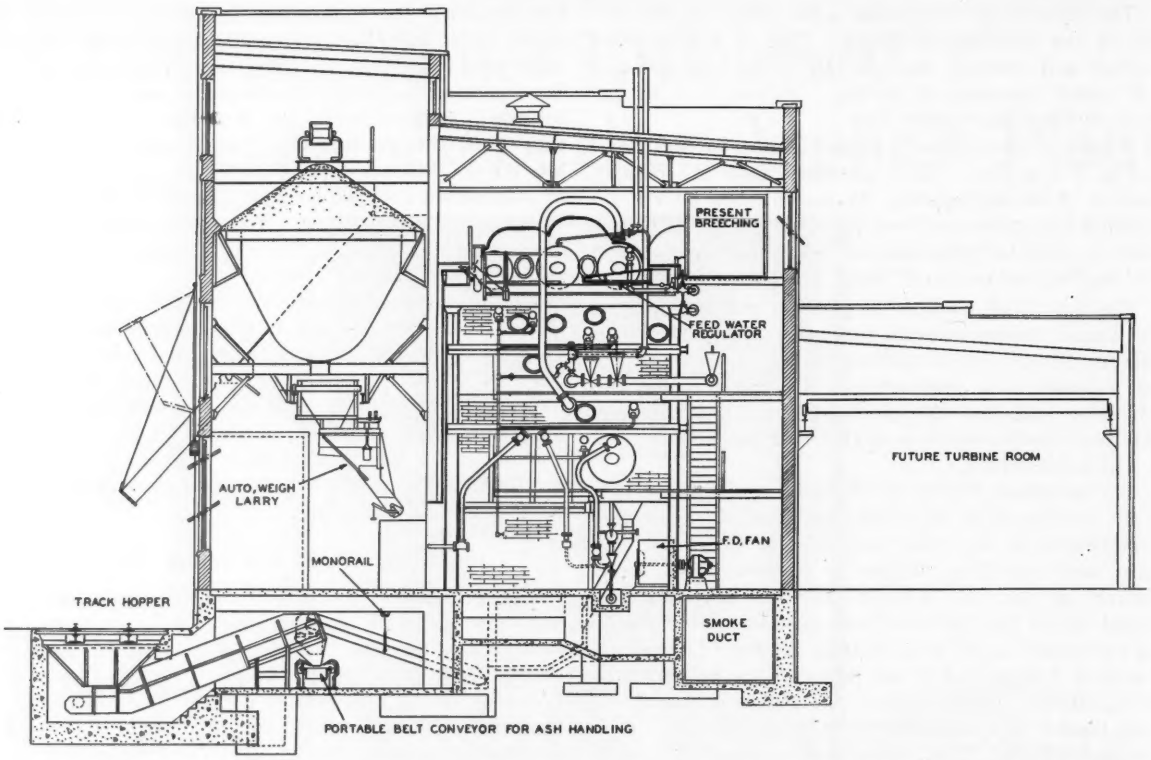


FIG. 2. SECTION THROUGH BOILER PLANT, SHOWING LOCATION OF FUTURE TURBINE ROOM

rheostats are arranged so that they may be connected or disconnected from the respective rheostats depending upon which boiler is in service.

In cutting over from one boiler to another, the incoming boiler is started up under natural draft. As the pressure approaches that of the line, the incoming boiler is cut in on the line and the fires on the outgoing boiler are reduced. Then, as the steam pressure on this (outgoing) boiler diminishes, the Carrick control is unhooked from this boiler so that both boilers are under hand control. After this the incoming boiler is operated under hand control for about 30 min., then it is put on the automatic control and is kept under this control until it is taken off the line again.

An interesting feature of the stoker installation is the manner of supplying secondary or "overfire" air. This, at present, is supplied by a small fan mounted between the two boilers as shown in the photograph at the head of this article. When the plant first was placed in service, overfire air was taken from the main forced draft duct but it was found that the pressure was not high enough. Then a steam jet was installed but this was noisy and unsatisfactory generally so the separate fan was installed. This proved highly satisfactory. This fan, a Buffalo steel plate fan with a capacity of 800 cu. ft. per min. at 10 oz. pressure, draws air from the forward part of the stoker enclosure which gives an air temperature of about 140 deg. At this temperature, it is delivered directly to the furnaces. This arrangement not only keeps the chain grate cool but the slightly preheated air so obtained adds to the efficiency of combustion. The stoker casing furthermore is maintained under a slight vacuum, a condition which entirely eliminates the emission of dust and smoke into the boiler room. This, together with the dust proof housing around the coal handling system already described, contributes to make this plant one of the cleanest boiler rooms the writer has ever seen. The Illinois stokers installed at this plant are entirely enclosed as may be noted from the accompanying photographs.

Under present "low steam pressure" conditions, the boilers are operated without economizers, but space has been provided behind the boilers for their installation when the plant goes on 400 lb. operation. As may be noted from the cross section, the present breeching to the stack is at the top of the boiler house. This breeching extends horizontally to the outside of the building into the stack. When the economizers are installed, however, they will be placed directly behind the boilers and the gases will pass downward into the concrete duct shown in the basement and then horizontally into the stack. Thus the installation of the economizers may be effected with the minimum of additional construction.

Another feature regarding the forced draft system which should have been mentioned is the fact that no metal duct is used, everything being of concrete. The main forced draft duct runs just below the rear of the furnaces. Only one forced draft fan is installed at present, this fan having capacity to serve only one boiler. Dampers are provided, however, so that this fan may be "switched" from one boiler to another. When the third boiler unit is added some time in the near future, another forced draft fan will be added. This will be placed adjacent to the present fan behind the (then) center boiler as shown on the plan, Fig 3. Thus, there will be two forced draft fans for three boilers, only two of which will be used at one time. The

forced draft duct to supply the future boiler is already installed.

Of unusual excellence is the boiler setting. Without the use of "sealing" paints or compounds, it is maintained absolutely tight at all times, no difficulty being experienced in keeping the CO_2 content in the last pass at 14 per cent. The designing engineers, in designing this setting, have used a special design of three rows of horizontal buckstays which tie into the main boiler columns. These buckstays act as a support to keep the furnace walls from bulging. Expansion is provided for at all four corners of the setting by using ½-in. staggered spaces filled with asbestos.

Each furnace is provided with two indicating draft gages, one a Defender "differential" multiple draft gage installed on the side wall of each furnace and the other a large illuminated, Republic multiple gage supported between the two boilers and visible from the firing aisle. Each of these gages gives pressure readings in the last pass, over the first as well as in each of the six stoker wind boxes. The Republic gages can be seen in the photograph at the head of this article. Between them can be seen another draft gage which indicates the pressure in the forced draft duct. This also is a Republic gage.

In addition to these gages there is still another, a large "over fire" draft indicator, mounted just above the Republic draft gages. This also is a Defender gage and is easily visible from the firing aisle. It can be used on whichever boiler is operating.

Thus it will be evident that this plant is well provided with means for determining the draft pressures in various parts of the system. The duplicate installation insures accuracy by continually checking the readings of one gage against those of the other.

The main Carrick combustion control "indicator" is also mounted between the boilers and visible from the firing aisle as shown in the photograph at the head of this article.

Many other instruments are provided. Each boiler has on its front, an indicating Republic CO_2 meter and steam flowmeter as well as an Ashcroft indicating pressure gage. Behind the boilers on a panel (shown in the headpiece) are mounted two sets of recording and integrating meters (one set for each boiler) recording steam flow, steam temperature, CO_2 and flue gas temperature. With the exception of a Sangamo clock all the meters on this panel are of Republic make.

Boilers are provided with the following accessories:

Bayer soot blowers, 6 units per boiler
Consolidated safety valves, 3 per boiler, 1 on superheater and 2 on the boiler drums
Yarway "Seesure" gage column with high and low level alarm
Crane feedwater stop and check valve
Copes feedwater regulator
Lunkenheimer boiler check valve
Crane boiler stop valve
Cochrane tandem blowoff valves.

Boiler Feedwater

All boiler feedwater used is well water. As the processes in which the water and steam are used contaminate it so as to make it unfit for further use, the make-up amounts to practically 100 per cent. All water is treated by the Cochrane hot process lime soda system, a water treating equipment of 10,000 gal. per hr. being provided. This equipment is located at one end of the boiler room and consists of a pressure filter, a chemical mixer and proportioner and a treating or sedimentation tank. The entire equipment with the exception of a

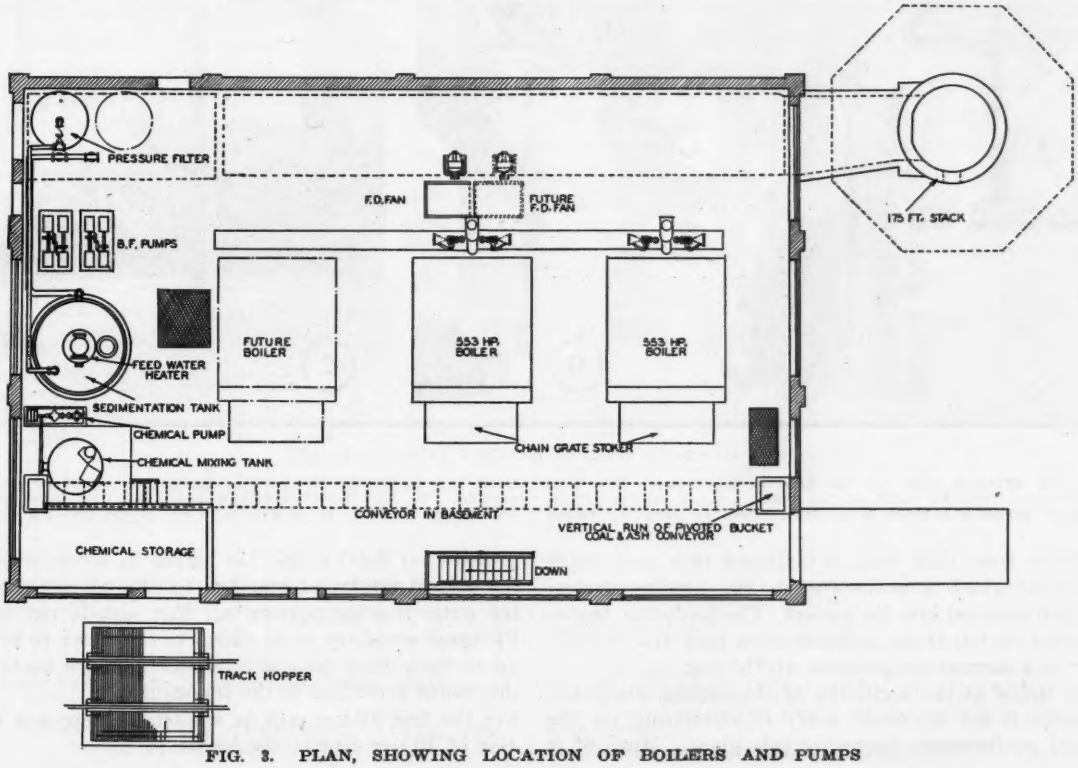


FIG. 3. PLAN, SHOWING LOCATION OF BOILERS AND PUMPS

Dean Hill centrifugal back wash pump is of Cochrane make.

Two Worthington boiler feed pumps are provided, one a duplex size 14 by 8½ by 10-in. unit, and the other a 10 by 6 by 10-in. unit. These are old pumps removed from the former boiler plant. They are fitted with Fisher differential pressure pump governors.

is due to the methods of operation used. In order to repay the operators for their share in maintaining efficient operation, bonus systems are made use of, one in connection with the percentage of CO_2 maintained and the other with the water treatment.

A bonus of $1.00 per day is paid to the operator for correct treatment. The measurement of this treatment

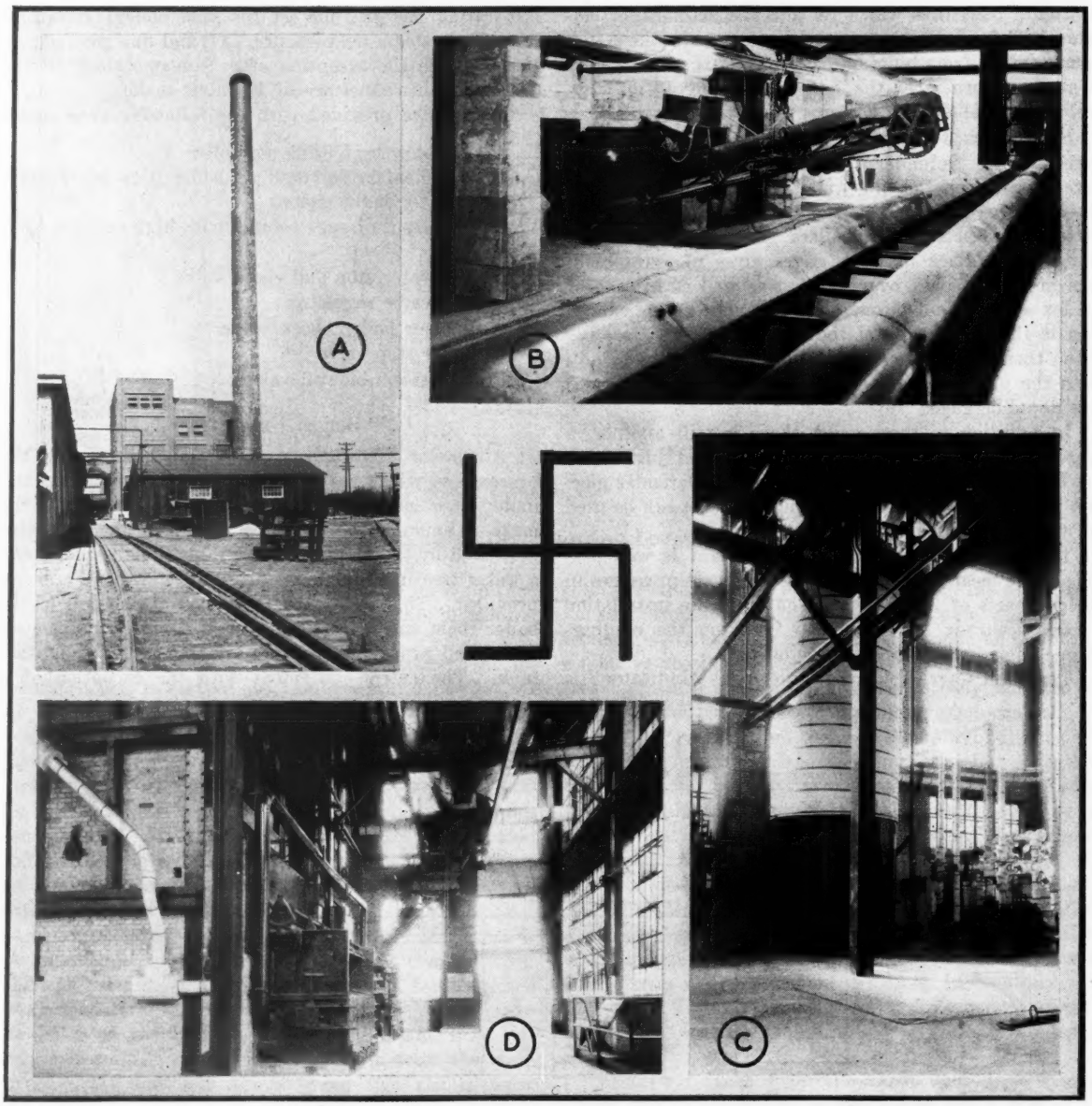


FIG. 4. VIEWS AT THE BARBER ASPHALT PLANT

A. An exterior view of the new boiler plant. The new turbine room will be built at the right. B. A portable belt conveyor suspended from a trolley serves to transfer ashes from the ashpits to the pivoted bucket conveyor in the foreground. C. The water treating sedimentation tank and the boiler feed pumps. D. A general view in the boiler room.

Water from deep wells is delivered to a steel tower tank from which it is drawn into the treating system and then pumped into the boilers. The feedwater heater is located on top of the sedimentation tank and delivers water at a normal temperature of 210 deg.

As stated at the beginning of this article, excellence of design is not the entire story in accounting for the efficient performance shown by this plant. Much of it is based on the Ph and Mo values in accordance with the correct treatment specified by the manufacturer of the water treating apparatus. For each 10 per cent of Ph value necessary to be added to the water to bring it up to the correct treatment, deductions are made from this bonus according to the following:

For the first 10 per cent or one-tenth, there is a reduction of 10 per cent of the bonus.

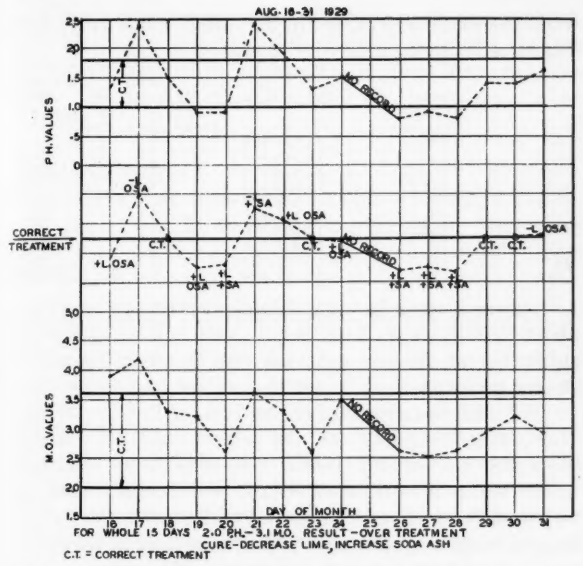


FIG. 5. CHART SHOWING EFFECT OF WATER TREATMENT FOR 15 DAYS BEFORE THE BONUS SYSTEM WAS INAUGURATED

For the second 10 per cent or one-tenth, there is an additional reduction of 15 per cent or 25 per cent total.

For the third 10 per cent or one-tenth, there is a further reduction of 25 per cent making a 50 per cent reduction in all.

For the fourth 10 per cent or one-tenth, all bonus is removed.

These figures are based on the average for each week and the results are made from tests made by the superintendent of maintenance and engineering.

The effectiveness of this bonus system may be judged by the accompanying charts, Figs. 5 and 6. One shows a record of the feedwater treatment for a period of 15 days before the bonus system was in effect. As will be noted, actual values vary considerably from the "correct" treatment. In the other chart, a similar record is shown but for a period when the bonus system was in effect. The actual scarcely varies from the required "correct" treatment.

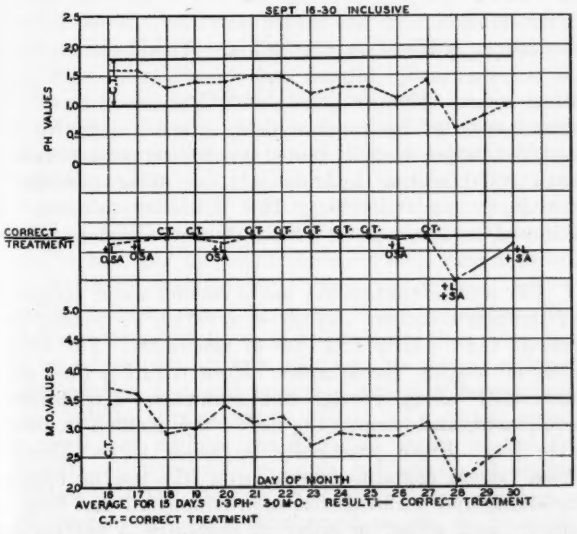


FIG. 6. CHART OF WATER TREATMENT, AFTER THE BONUS SYSTEM WAS IN USE

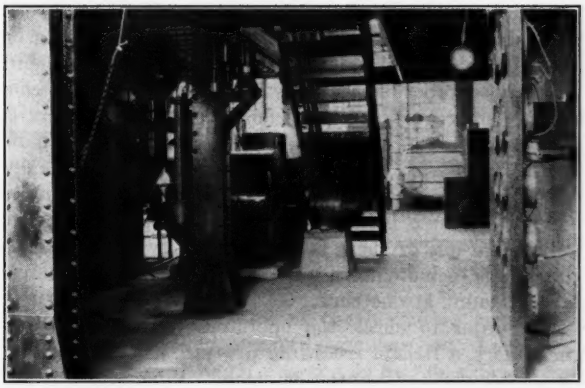


FIG. 7. VIEW BEHIND BOILERS SHOWING FORCED DRAFT FAN

Before this system went into effect, the operators were careless as to the quantities of lime and soda ash used in the treatment—a pound or more, one way or the other made little difference—but now they weigh the chemicals to the last ounce.

The bonus system for CO_2 is equally effective and since its inauguration there has been no difficulty in keeping the CO_2 at between 12 and 14 per cent. The system is based upon the weekly average of CO_2 maintained for values over 10 per cent. For a CO_2 average of 10 per cent for the week, a bonus of 30 cents a day is paid and for each half of one per cent CO_2 above 10 per cent (up to 14 per cent) an additional bonus is paid.

With these plans, the operators are very careful to maintain proper operating conditions and take a decided interest in their work.

TYPICAL COAL ANALYSIS

	Madison, Illinois 1-24-30		
ANALYSIS OF THE COAL.	AS RECEIVED.	AIR DRIED	ABSOLUTELY DRY
Moisture	17.40%	9.00%	None
Volatile matter	33.20%	36.60%	40.20%
Fixed Carbon	36.15%	39.80%	43.75%
Ash	13.25%	14.60%	16.05%
	100.00%	100.00%	100.00%
Sulphur	3.46%	3.81%	4.19%
Calorific power	9,900	10,905	11,985 BTU
ANALYSIS OF THE ASHES			
Combustible Carbon as Coke	14.15%		
Non-combustible	85.85%		
	100.00%		
The following is the composition of the non-combustible dry ashes			
Silica	44.10%		
Alumina	18.09%		
Iron sesqui-oxide	22.79%		
Lime	11.90%		
Magnesia	1.25%		
Sulphuric Anhydride	1.74%		
	99.87%		

The fusing point of this Ash will be approximately 2050° F which is almost the low limit of fusibility of Ash. An ash would have to be much higher in silica to have a high fusing point. This ash willclinker easily, when exposed to more than 2000° F of heat.

Since the plant has been operating, there have been practically no repairs with the exception of washing or coating the furnace walls with high temperature cement. With the proper treatment, the water forms no scale on the boiler surfaces. Concentration in the boilers is kept between 600 and 700 grains per gal. and the blow down is regulated accordingly. This concentration may seem high, but it is entirely satisfactory with the ratings carried on these boilers. Each boiler has two blowoff valves and one of these is blown every two hours. The practice is to blow down a little at a time rather than a large amount at one time.

In order to check the operators in blowing down the boilers, a Bristol recording pressure gage is installed on the blowoff tank in the basement. Whenever a boiler is blown off, the pressure in the tank rises and a record of this pressure rise is made on the chart.

Conclusion

In concluding this article, it may be of interest to present a summary of operation from September, 1929, when the plant was placed in operation, until July, 1930. This is as follows:

	Coal as fired Tons	Lb. Steam	Actual Evaporation in lb. coal as fired—B.t.u. 9900	Average CO_2 per cent
Sept.	751.0	11,176,400	7.4	....
Oct.	887.2	13,848,900	7.8	10.4
Nov.	814.6	14,015,850	7.5	10.6
Dec.	949.3	13,999,950	7.4	11.5
Jan.	1006.1	15,189,800	7.5	12.0
Feb.	824.3	11,925,000	7.2	12.1
Mar.	959.6	14,029,100	7.3	12.9
Apr.	912.6	13,658,100	7.5	12.8
May	787.4	12,131,700	7.7	12.8
June	711.9	11,771,300	8.3	12.7

The coal used is wash Illinois screenings averaging about 9900 B.t.u. as fired per lb. with some 3½ per cent sulphur and 13 per cent ash. A typical analysis is shown herewith.

We wish to acknowledge our indebtedness to Wm. J. Hart, chief engineer of the plant, and to Baumes-McDevitt Co. of St. Louis, the consulting engineers, under whose directions the plant was designed and constructed, for assistance rendered and courtesies extended in gathering the data on which this article is based.

Easy Determination of Boiler Water Sulphates

Benzidine Method of Sulphate Determination Is Rapid and Gives Almost Laboratory Accurate Results. Unfiltered, Hot or Cold Water Samples May Be Used. By J. A. Holmes*

WITH THE ADVENT of boiler plate embrittlement theories and the consequent necessity for the control of the ratios of total alkalinity to sodium sulphate, rapid and easy methods for determining sulphates in boiler water are necessary. Any method adopted for routine control in the power plant must be such that it requires a minimum of time and is simple in operation. Also the procedure must be consistently accurate.

Laboratory Determination, a Slow Process

Accurate laboratory determination of sulphates is by the precipitation of the sulphates with barium chloride and the filtering, burning and weighing of the precipitate. This requires considerable time, equipment and, usually, the service of a chemist. The rapid methods for determining sulphates most commonly used require either photometers, hydrometers or electrical conductivity measuring instruments. The photometric method or the precipitation of sulphates by barium chloride and the measuring of the resultant turbidity, has probably been one of the most popular. The chief difficulty with this method has been the variation of particle size, the same concentration of sulphates not always having the same degree of light penetration. Also this method is not adaptable to water of low sulphate content. Neither is this method of sulphate determination adaptable for portable kit operation.

Measurements of the specific gravity of boiler water by sensitive hydrometers is another method for determining sulphates. The total dissolved solids is usually determined by the hydrometer, while the sodium hydroxide, sodium carbonate and sodium chloride of the boiler water are calculated by titration with standard solutions. Thus the difference between the total dissolved solids and the sum of the sodium chlorides, sodium hydrate and sodium carbonate is calculated as the sodium sulphate content of the boiler water. The presence of large quantities of silica, alumina, or organic matter, however, tends to cause error in the calculation nor is the use of the hydrometer advisable for total dissolved solids under 50 gr. per gal. This instrument, however, is adaptable to portable kits. The main objections to the electrical conductivity method are the same as for the hydrometer and the initial cost of conductivity aparatus is quite high.

Benzidine Method Requires Small Samples Only

Originally the benzidine method for determining sulphates in boiler water required a 250-cc. sample of water to which 10 cc. of 1 per cent solution of hydroxylamine hydrochloride first was added and then 20 cc. of the benzidine hydrochloride solution. This solution was stirred vigorously, filtered and washed twice with distilled water. The precipitate and filter paper was then transferred to the original flask, a small quantity of distilled water added, heated to boiling and titrated with N/20 sodium hydrate solution using phenolphthalein as an indicator. This procedure should be followed in laboratories where accurate determinations are desired.

For routine control, the use of smaller water samples, of stronger solutions and the elimination of heating increases the rapidity and ease of procedure. The omission of heating the samples before titration does not materially affect results but eliminates considerable equipment, and permits the use of this method in portable kits. Since practically no water taken directly from boilers contains ferrous iron, the use of hydroxylamine hydrochloride has been eliminated and hydrochloric acid added in order to neutralize a portion of the alkalinity of the boiler water.

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Close approximation to the barium chloride laboratory method is the benzidine method in which the following equipment is required: 1. Benzidine solution. Made by dissolving 11.2 grams of benzidine hydrochloride in 400 cc. of water and mixing with 100 cc. of 5 per cent solution of hydrochloric acid. 2. Ten cc. pipette or graduate. 3. Graduated cylinder. 4. 250 cc. Erlenmeyer flask with rubber stopper or glass stoppered 8-oz. bottle. 5. 10 or 25 cc. burette with glass cock. 6. N—0.14 sodium hydroxide solution. 7. Filter paper and funnel.

Procedure for Benzidine Method of Determination

1. Estimate if possible approximate amount of sodium sulphate and if between: 0 to 100 gr. per gal. use 58.3 cc. of water; 100 to 200 gr. per gal. use 29.2 cc., and if 200 to 400 gr. per gal. use 14.6 cc. of water.

2. If using half or quarter sample of water, make up to 58.3 cc. with distilled water.

3. Place in a 250-cc. Erlenmeyer flask, add 10.0 cc. of benzidine solution and mix by giving whirling motion.

4. Filter off suspended solids discarding filtrate unless cloudy, in which case pass through filter paper again. To tell whether all sulphates have been precipitated, drop one drop of benzidine solution into clear filtrate. If the solution turns cloudy, start procedure over with a small sample of water.

5. Rinse emptied flask with approximately 25 cc. of distilled water, using the rinse water to wash the sulphate precipitate. This is done by first letting the original solution filter through completely and then pouring the distilled water over the precipitate in the funnel in two or three equal proportions, allowing each application of water to pass completely through before more is added.

6. Carefully remove the filter paper with washed precipitate from the funnel, place in original flask and add approximately 25 cc. of distilled water.

7. Add two drops of phenolphthalein indicator and then sodium hydrate solution through a burette until a pink color, which will remain for ½ minute, results. Titration should be done by imparting a swirling motion to the flask during initial stages and then completing the operation by placing a rubber stopper in the flask and shaking after each addition of sodium hydrate solution. This will insure breaking up the filter paper.

Calculation of Results

Multiplying the number of cubic centimeters used by ten gives the amount of sulphate present as sodium sulphate grains per gallon. If more than 10 cc. are required to get the P reading, start the procedure over with a smaller sample. If ½ or ¼ sample is used, be sure to multiply by two or four respectively.

If water contains more than 400 gr. per gal. of sodium sulphate, use a ¼ sample and 20 cc. of benzidine solution instead of 10 cc. If titration is then more than 20 cc. of sodium hydrate solution, use 30 cc. of benzidine solution and add enough distilled water to make total volume approximately 150 cc. To obtain results in parts per million, use 50 cc. of water or fraction thereof and multiply the cubic centimeters of sodium hydrate solution used by 200. If a large number of low content sulphate determinations are to be made, use N—0.014 sodium hydrate solution.

Comparative determination of sulphates in boiler waters by the regular gravimetric or laboratory procedure as compared with the benzidine method are shown in the tables.

The time consumed for the gravimetric method averaged from 8 to 12 hr. whereas with the benzidine method the average time consumed was less than 5 min. The samples shown in the table were selected because they were either highly colored, contained large amounts of soluble silica or alumina or have some other factor that might be expected to influence the benzidine reactions.

Over 100 comparisons of the benzidine method, as against the barium precipitation method, have been made and they show an average of less than 3 per cent error. This percentage of error could be reduced by using larger samples and more dilute solutions, however, any method which would give under 5 per cent maximum error is considered sufficiently accurate for routine control.

COMPARATIVE RESULTS OF GRAVIMETRIC AND BENZIDINE TEST METHODS. RESULTS ARE EXPRESSED IN GRAINS PER GALLON

Lab. No.	Gravimetric	Benzidine	Characteristics
1440	35.6	33.5	Colored
1441	52.5	51.5	Colored
1442	57.0	54.5	Colored
1443	4.76	5.0	Low sulphates
1455	92.9	89.5	Heavy organic
1459	9.3	9.0	Low sulphates
1460	62.8	61.0	High alkalinity
1461	22.7	22.0	Oil and high alumina
1471	6.0	5.5	Heavy phosphate turbidity
1486	6.8	6.5	Low sulphates

Advantages of Benzidine Method

Principal advantages of the benzidine method are, therefore, simplicity of operation, speed, accuracy and the fact that it is not influenced by the presence of constituents ordinarily encountered in boiler water nor by temperature variation. Sulphate can thus be run on either filtered or unfiltered, hot or cold samples. For these reasons, the benzidine method is especially adaptable for routine control in power plants, for portable kit field operation and for chemical laboratories where a large number of samples are analyzed daily. In laboratories where larger samples and more dilute solutions are used, there is no reason why the method will not produce results which will not vary over 1 per cent from actual sulphate content.

Two Dutch scientists, in 1823, by means of cannons about 11 mi. apart determined the velocity of sound as 1093 ft. per sec. Later experiments found that at 32 deg. F. and atmospheric pressure the velocity is 1087 ft. per sec. and that it increases about 1.3 ft. per sec. for each degree F. rise in temperature. For practical purposes, the figure 1100 ft. per sec. is used. In water, the speed is 4.5 times and in steel 15 times more than in air.

What Method Should be Used to Give a Fair

Comparison of Steam Station Performance

In the June 15 issue, Professor Christie proposed a new method of comparing steam station performance. This method involved the use of two constants and the capacity factor. The two following articles, the first by E. B. Ripley, Production Engineer of The Connecticut Light & Power Co., and the second by H. L. H. Smith, Research Engineer of the New England Power Construction Co., point out what they think are the limitations and advantages of Professor Christie's method.

By E. B. Ripley
Production Engineer, The Connecticut Light & Power Co.
Waterbury, Conn.

PROFESSOR CHRISTIE'S method of comparison of steam station performance is a real advance over the method of expressing results in B.t.u. per kw-hr. without regard to condition of station operation. The former method did not distinguish between the station working on base load in a metropolitan district, and the relay steam plant designed to operate in connection with a hydro station.

Operating men can find this method of considerable assistance when confronted by a high coal rate and a low load. It is easy, but not always successful, to explain the former by pointing to the latter. The low load, taken by itself, does not show how high the coal rate should be expected to go. Professor Christie's method, however, gives a perfectly definite yardstick by which the results may be measured and the general trend of station operation can be determined under the varying conditions of actual operation.

He did not particularly stress one of the outstanding features of the method. This comparison can be made on any steam plant without expensive tests or complicated calculations. It can be made from records that are kept in every station, and can therefore be extended over any desirable period of time. All that is necessary is the log of station output, the log of coal burned and a piece of cross-section paper. It makes little difference whether the results are kept on a daily, weekly, or monthly basis. When the pounds of coal, or B.t.u.'s for the period, are plotted against the output for the same period, a series of points result. When there is a sufficient range in output, these points fall in a narrow band through which a line may be drawn. This line represents the input-output curve described by Professor Christie.

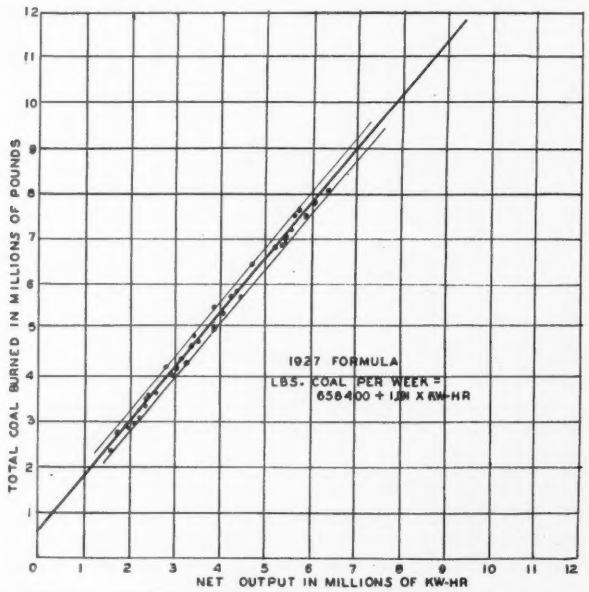
TOTAL COAL BURNED IN MILLIONS OF POUNDS
NET OUTPUT IN MILLIONS OF KW-HR
1927 FORMULA
LBS. COAL PER WEEK =
658400 + 1.01 X KW-HR
0 1 2 3 4 5 6 7 8 9 10 11 12

FIG. 1. STEAM STATION PERFORMANCE FOR COAL BURNED PER WEEK

In making up such curves, the width of this band, or the amount of "scatter" in the points plotted is of some interest. In general, the more carefully the station is operated, the narrower the band will be. If correction is made for the variation in the amount of coal in the stoker hoppers and the amount in the fuel beds at the end of the period, the scatter is reduced. Any limitation in fuel weighing equipment shows up in the width of the band of points. For instance, a certain station has equipment for measuring coal into the bunkers, but relies on counters to measure the coal fed into the furnaces. Daily results are computed from counter readings, which are affected by such factors as moisture content and lumpiness of coal. Once a week, the bunkers are carefully filled to a definite level and readings taken on the amount of coal delivered to the bunkers. In this station, the scatter is much more pronounced for the band of points plotted from daily figures than is the scatter from the weekly results.

It is also interesting to note that the band is usually of approximately uniform width, where a sufficient number of points is taken. In other words, the upper and lower limits of the band of points are approximately parallel. Now, if the scatter was due to errors, to variations in vacuum, as suggested by Professor Christie, or to variations under the control of the operators, it is reasonable to suppose that the variations would result in errors of the same order of magnitude in terms of percentage error. If this supposition were correct, the lines would not be parallel but divergent and noticeably so. The author of this discussion has not seen a group of input-output points plotted where the boundary lines diverge noticeably.

Why is it, then, that the percentage error is so much less at high output than at low? This result certainly does not square with the ordinary boiler room difficulty in keeping fires in condition at maximum rating. It is true that vacuum correction factors, expressed in percentages, are lower at the higher loads on the machines.

Careful study of available material, however, does not show any definite agreement between circulating water temperature and position of the points in the band.

In a system involving both hydro and steam, high steam station outputs are almost invariably associated with the low hydro output of the summer months; hence, with high circulating water temperatures and low vacua. In this case, therefore, variations in vacuum will be taken care of in the general slope of the band of points and some other explanation will have to be found for the width of the band.

Another curious point comes up in connection with the input-output curves. If a set of curves is plotted for a given station on both a weekly and a daily basis and the position of the average line determined mathematically, the slopes of the two lines are not the same, nor is the intercept of the daily curve one-seventh of the intercept of the weekly curve, even though the periods covered by the figures are the same. Inaccuracies in daily figures as mentioned above may account for this discrepancy, which is relatively small. The true explanation, in the author's opinion, lies in this fact: In the weekly figures, the Sunday low output is a part of the whole, whereas it is a point by itself in the daily figures.

A third point in connection with these curves was discovered by accident and came as something of a shock to the author. In a certain steam plant, having three generators, it is customary to overhaul the turbines annually, during the high water period. This results in a period of 13 to 15 wks. when there are available only two machines. Input-output curves were plotted for these weeks in 1927 and a separate set was plotted for the weeks when the three machines were used. The result was surprising, in that the slope of the two curves were identical while the intercept was higher in the three machine weeks. Figure 2 shows the two curves compared with a curve drawn for the year 1927.

These points are interesting in connection with the use of the input-output curves and are perhaps true. The author is quite ready to admit that he has not proved them conclusively. If they are true, however, the input-output curves and the expression derived therefrom by Professor Christie, vary with the conditions of plant operation. If the "constants" in the expression do vary with the change in conditions, then the expression is not an absolute measure of station performance and suffers, though to a much less degree, the same disadvantages as attach to the user of the straight B.t.u. per kilowatt-hour generated.

Formulas proposed by Professor Christie are as follows:

$$\text{Total B.t.u.} = A \times \text{Kw-hr.} + B$$

$$\text{B.t.u. per Kw-hr.} = \frac{A + B}{\text{Capacity Factor}}$$

In any station using uniform coal over a long period, these formulas may just as well be expressed in terms of pounds of coal, as follows:

$$\text{Total Coal} = a \times \text{Kw-hr.} + b$$

$$\text{Lb. Coal per Kw-hr.} = a + \frac{b}{\text{Capacity Factor}}$$

where a = A ÷ B.t.u. per pound of coal

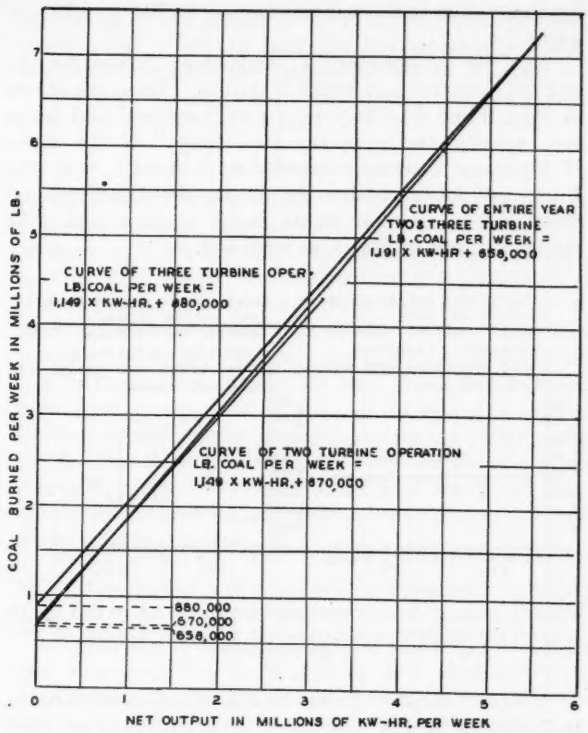
COAL BURNED PER WEEK IN MILLIONS OF LB.
NET OUTPUT IN MILLIONS OF KW-HR. PER WEEK
CURVE OF ENTIRE YEAR TWO & THREE TURBINE LB. COAL PER WEEK = 1.191 X KW-HR + 658,000
CURVE OF THREE TURBINE OPER. LB. COAL PER WEEK = 1.149 X KW-HR. + 880,000
CURVE OF TWO TURBINE OPERATION LB. COAL PER WEEK = 1.149 X KW-HR. + 670,000
880,000
670,000
658,000

FIG. 2. STATION PERFORMANCE SHOWING THE EFFECT OF THE NUMBER OF UNITS OPERATING

From the first form of this expression, a useful corollary may be developed if we express the formula in words. We have written: The pounds of coal burned equals a constant plus a constant times the kilowatt-hours generated. This is simply another way of saying that if you generate a kw-hr. in addition to any given amount, you will burn "a" pounds of coal per kw-hr. for every additional kw-hr. generated no matter at what time of day or night the additional amount of energy may be produced.

In other words, the incremental fuel cost of energy is constant, regardless of load, load factor, peak carried or anything else. This formula is often called an incremental formula, for this reason.

The other corollary comes most easily from the second form of the expression. At equal capacity factors, the B.t.u. per kw-hr. should be the same, regardless of load factor or peak.

In order to have quantitative figures for the discussion of these points, some figures will be taken from the records and studies made on the steam station mentioned above. The incremental formula has long been used in the study of the operation of this plant. There is, in addition, a fairly well authenticated bogey made up from guarantee figures and results of tests by theoretical methods. This bogey indicates the amount of coal which should be burned per hour at any condition of load and with one, two or three units in operation.

The station is very well suited to studies of this kind since the three 25,000-kw. turbines are identical, the eight boilers are identical in size and all eight stokers are nearly the same. Four of the boilers are equipped with identical economizers. The incremental formula

for the station is lb. coal per day = 94,700 + 1.191 × kw-hr.

Now let us consider two daily load curves for the station, neither one of which is typical. These are shown in Figs. 3 and 4. The total kw-hr. produced and hence the capacity factor in the two "days" is the same. If Professor Christie's expression is strictly true, the B.t.u. per kilowatt-hour should be the same, yet no steam station operator would expect to do as well with the load shown in Fig. 4, as with Fig. 3.

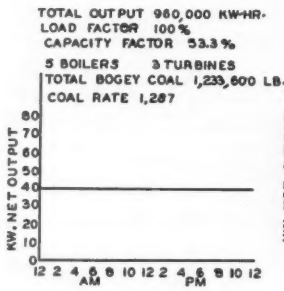
TOTAL OUTPUT 960,000 KW-HR.
LOAD FACTOR 100%
CAPACITY FACTOR 53.3%
5 BOILERS 3 TURBINES
TOTAL BOGEY COAL 1,233,600 LB.
COAL RATE 1.287
KW. NET OUTPUT
12 2 4 6 8 10 12 2 4 6 8 10 12
AM PM

FIG. 3

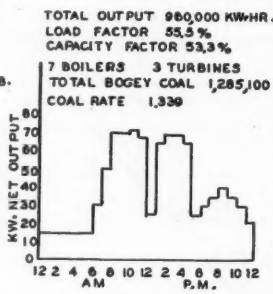
TOTAL OUTPUT 960,000 KW-HR.
LOAD FACTOR 55.5%
CAPACITY FACTOR 53.3%
7 BOILERS 3 TURBINES
TOTAL BOGEY COAL 1,285,100 LB.
COAL RATE 1.339
KW. NET OUTPUT
12 2 4 6 8 10 12 2 4 6 8 10 12
AM P.M.

FIG. 4

FIGS. 3 AND 4. TWO DIFFERENT LOADS SHOWING THAT A CONSIDERATION OF CAPACITY FACTOR ALONE IS NOT SUFFICIENT

Coal consumption from the above increment formula is 1,237,360 lb. for both days, or a coal rate of 1.289 lb. per kilowatt-hour. Yet the bogey sheet gives 1,233,600 lb. for Fig. 3, a rate of 1.287 lb. per kilowatt-hour, and 1,285,100 lb. for Fig. 4, or 1.339 lb. per kilowatt-hour. These results seem much more reasonable than the results from the incremental formula.

In order to analyze further the theory that incremental cost of energy is always a constant, let us consider the load curve shown in Fig. 5. The unshaded portion represents the normal load, and the shaded portion represents an added increment of 250,000 kw-hr., which is presumed to recur daily during the working days. From the incremental formula above, the incremental fuel chargeable to these kw-hr. would be 1.191 × 250,000 = 297,750 lb.

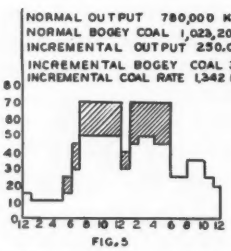
NORMAL OUTPUT 780,000 KW-HR.
NORMAL BOGEY COAL 1,023,200 LB.
INCREMENTAL OUTPUT 250,000 KW-HR.
INCREMENTAL BOGEY COAL 335,400 LB.
INCREMENTAL COAL RATE 1.342 LB.
12 2 4 6 8 10 12 2 4 6 8 10 12

FIG. 5

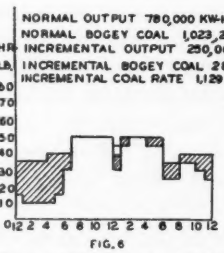
NORMAL OUTPUT 780,000 KW-HR.
NORMAL BOGEY COAL 1,023,200 LB.
INCREMENTAL OUTPUT 250,000 KW-HR.
INCREMENTAL BOGEY COAL 282,400 LB.
INCREMENTAL COAL RATE 1.129 LB.
12 2 4 6 8 10 12 2 4 6 8 10 12

FIG. 6

FIGS. 5 AND 6. TYPICAL LOAD CURVES TO SHOW THAT THE INCREMENTAL FEED IS THE SAME FOR EQUAL LOAD INCREASES

Figure 6 represents the same normal load curve, unshaded, and a shaded increment of 250,000 kw-hr. applied in such a way as to increase rather than decrease the load factor. If our incremental theory is correct, the incremental fuel is exactly the same, 297,750 lb. The bogey sheet, however, says otherwise. The fuel chargeable to the increment of Fig. 5 is 335,400 lb., or 1.342 lb. per kw-hr., while that chargeable to Fig. 6 is 282,400 lb. or only 1.129 lb. per kw-hr. The bogey sheet has proven more accurate in practice than the incremental formula and its results are more in accordance with common experience.

The author believes that the incremental formula and the expression derived therefrom by Professor Christie are of great value for determination of the performance of any given steam station, as long as the general character of the load does not materially change. This formula is of material assistance in preparing estimates of coal consumption for budget purposes from year to year. He does not believe that the expression is of great value in the comparison of different stations on widely different loads. He believes that it is positively dangerous in certain uses, such as a decision (when new capacity is necessary) between hydro and steam.

In conclusion, the only entirely satisfactory method of keeping track of steam station results, according to the author's experience, is based on an hour by hour study of the actual load carried, with due consideration given to items such as banked boilers, circulating water temperatures and possible superheat. Such a study is, of course, too cumbersome to be used for forecasting future results. For the latter purpose, the approximate formula must consider peak, as well as kw-hr.; that is to say, load factor, as well as capacity factor.

By H. L. H. Smith
Research Engineer
New England Power Construction Co., Boston, Massachusetts

PROFESSOR CHRISTIE discusses the subject fundamentally upon the basis of the "Parson's Line" after changing the dependent variable to a B.t.u. basis. There is emphasis in the title and to some extent throughout the article, that comparison of a steam station performance with the performance of other steam stations is the point of first interest and the aspect of the subject most in need of clarification. A second point in the article which receives stress is Professor Christie's preference for capacity factor rather than load factor as a constituent part of station performance analysis.

Professor Christie says, on page 673, "Station performance may be represented by an input-output curve." Rather than this, it seems to the writer that the main point in station performance analysis is to explain the input. The input should be put in the place of dependent variable and kept there unalloyed. It is then the problem of station performance analysis to explain it, that is to set over against it the requisite independent variables, each with its own coefficient, which, if the analysis were successful, would remain invariant while the station in question experienced no significant changes in equipment.

The problem of whether these coefficients, invariant for any one station in any specific stage of its development, remain anything like invariant when comparing different steam stations or when comparing significantly different stages of development of the same station, or whether, while not invariant in themselves, they contain factors which are invariant in a comparison of different stations or different equipment stages of the same station, is a problem in itself, a secondary problem, nevertheless one of real importance.

Professor Christie's treatment, it seems to me, does

not keep clear the distinctions between these problems, that of explaining adequately the input of a given station in terms of its general performance (not merely in terms of its output), and that of comparing different power stations and explaining the comparison. He first considers the relation, which in slightly modified nomenclature, intended to keep clear the distinction between station variables and term coefficients, is:

$$H = a\,K + b$$

where H = total heat input in a given period
K = kilowatt-hours in the same interval.
a and b = constants.

Then he takes the somewhat curious step of multiplying and dividing one term, and at that an approximately constant term, of this equation by the same quantity. That is, in essence his argument proceeds by making use of the relation:

$$H = a\,K + b\frac{\frac{1}{CT}}{\frac{1}{CT}}$$

He then divides this equation by K, obtaining:

$$\frac{H}{K} = a + \frac{\frac{b}{CT}}{\frac{K}{CT}}$$

He then comments that if b is constant $\frac{b}{CT}$ is also constant, C representing the station rated capacity and T representing the time interval in question. From then on he designates $\frac{b}{CT}$ as d and points out that $\frac{CT}{K}$ is the station capacity factor. The comparison between different stations which he cites and the comparison between various stages of equipment of a single station show that d is not constant, but makes some approximation to being so.

d Only Approximates a Constant

It is obvious that in the general Parson's Line relationship on a heat basis,

$H = a\,K + b$ the term b is the heat input which is independent of station output. Dividing it by the product of C and T is the same thing as dividing it first by T and then by C (or vice versa as one likes). Dividing b by T gives the heat input per hour which is independent of station output and then further dividing by C gives the heat input per hour per kilowatt of rated capacity which is independent of station output. It is this which Professor Christie designates by d (allowing for my slight change of nonenclature) and which his instances indicate is somewhere near constant for various stations and for various stages of equipment of a single station.

More fundamental, it seems to me, is the concept that as a first approximation only the heat input of a station is to be explained by the relation:

$$H = a\,K + b$$

But like most first approximations it is the most important step which can be taken to explain station heat input. It is not sufficient in itself, nor are the coefficients a and b proved constant, but no equally simple relation of comparable importance can be written.

If we go on and write some further terms, however, we might do well, adding one, to write:

$$H = a\,K + b\,P + c$$

where P = station peak load in the interval. The interval in question may be a day or a week or a month or even a longer period. As Professor Christie says, peak load is ordinarily measured as the kilowatt-hour output in a quite short interval, perhaps 20 min., so we might do well to take the average of all such peak loads in each interval of a week or a month, rather than merely the highest one of the lot. It would obviously have been no advance in writing an equation beyond the first approximation to use C, the station rated capacity, for this rated capacity for a given station in a given stage of development is constant and we would have only been multiplying one approximate constant by another genuine constant.

Multiplying One Approximate Constant by Another Gains Nothing

If this new equation, elaborated one step beyond the first approximation, is divided by K it obviously leads by simple manipulation to load factor; and thus if one gets away from mere consideration of the heat input as dependent variable and goes over to the hybrid unit heat input per kilowatt-hour output, load factor gets into the picture; whereas nothing is really gained, as pointed out above, by multiplying one approximate constant by another constant, and so after dividing by the kilowatt-hour output, bringing station capacity factor into the picture.

The main point, however, is that we should stick to the problem of heat input as dependent variable, and see if it can be explained in terms of independent variables. So far we have the independent variables K, the station output in a given interval, and P, the station peak load in the same interval. Now, some seem to think that P is not a genuinely important independent variable in steam station operation. Unquestionably it is vastly more important in some stations than in others but in these days of tie-ins with base load steam stations, not to speak of tie-ins with hydroelectric generating equipment, the number of stations which in a given year would show wide variation of peak load throughout the various months, not to speak of various weeks of a year, is great in this country and analysis of their performance is obviously of increasing importance.

After all the real problem, probably best not more than touched upon at this time, is that of statistical analysis applied to steam station performance. What correlation coefficient exists between H and K in the simple relation $H = a\,K + b$? The answer is that for practically any station in any interval representing no significant change of equipment the correlation is high and has long been known to be high and this is the justification for the vogue of the Parson's Line on a heat unit basis. But may the correlation be raised higher by making it a multiple correlation problem? Does it go significantly higher when the equation is written $H = a\,K + b\,P + c$? How much does the multiple correlation coefficient fall down when the term

c is stricken off and the equation written H = a + K + b P, making possible a single line relationship between B.t.u. per kilowatt-hour and load factor, a relationship not infrequently seen in the literature of station economics?

Going back to the more legitimate form H = a K + b P + c, how much can the multiple correlation coefficient be still further raised by adding still another term, making the equation H = a K + b P + c T + d, where T = average temperature of intake condensing water? This latter form takes three independent variables of station performance and attempts with them to explain the dependent variable, the heat input. As such it is fairly powerful. Would the coefficients of such an equation, a, b, c and d, really prove invariant through repeated seasons of a station's operation without significant change of station equipment; and then the question, how would such coefficients for stations of different size and different design show themselves to be related, more or less in the fashion of Professor Christie's changing the constant b to the constant d, that is changing heat consumption independent of output in the elementary relationship to heat consumption per hour per kilowatt of rated capacity in the equally elementary relation? I believe we shall not wait long before applications of modern statistical analysis in the field of multiple correlation will give us illuminating answers to these questions.

Power in the Steel Industry

STEAM FROM WASTE FUELS. AUTOMATIC FUEL CONTROL. PRESSURE LIMIT.* BY CHARLES W. E. CLARKE†

GROWTH of the steel industry during the past 30 yr. has been tremendous, as indicated by Fig. 1, and power facilities have had to expand accordingly. In the early days, pressures were low, boiler and engine

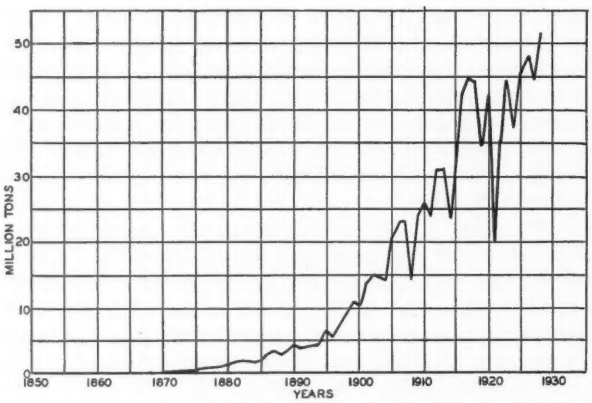

FIG. 1. INCREASE IN STEEL PRODUCTION

units small and efficiency poor, resulting in a multiplicity of plants located near to points of large steam and power use. Natural development was to increase capacity along the line of early installations, so that large investment was made in systems not well fitted for large capacity. Where more modern installations were added, a mixture resulted which seemed only to complicate the problem of bringing the whole system to a condition of modern efficiency.

Starting in 1905 with 50,000 hp., motor drive has increased to some 2,300,000 hp. at the end of 1928 for main mills, while ingot production was increasing 2½ times, and new mills are almost universally motor driven. The question to be solved was and is, how shall development of steam systems be carried out? This covers fuels, types of steam generation, pressures and operating economy, taking advantage of the large quantities of waste heat and fuels available.

*From a paper before the World Power Conference, Berlin, June, 1930.

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FACTORS IN STEAM PRODUCTION

Factors involved are: Power and steam loads and their fluctuation; water available for boilers and condensers; waste fuels and heat available; probable future development.

Ingenuity is needed to determine the steam load on the boiler plant but coal fired, probable boiler efficiency, water measurement, will give a reasonable, basis for constructing an estimated load duration curve which can be compared with the supply of waste fuels available.

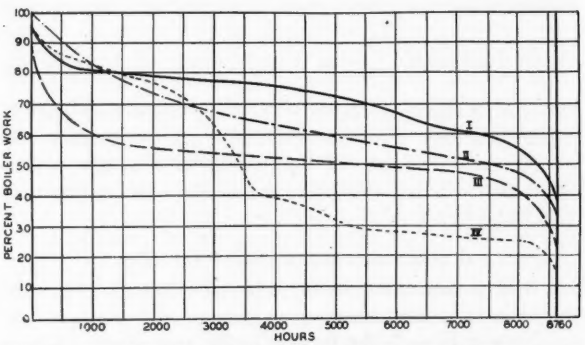


FIG. 2. RELATION OF POWER DEMANDS AND HOURS OF USE FOR STEEL PLANTS

Figure 2 shows for four plants the hours per year during which various boiler outputs are required. Plant I operates 24 hr. a day most of the time, producing yearly 1,250,000 t. of ingots for pipe, sheets and wire. Plant II produces 650,000 t. for pipe and wire, with less full time operation. Plant III produces 400,000 t. for small shapes and reinforcing rods on part full time. Plant IV, operating mostly on one shift a day, produces 180,000 t. for small shapes and wire products. All plants have blast furnaces and process from ore to finished product. They cover a wide range in capacity and operating conditions yet load duration curves are somewhat similar in character.

Evidently plant design will depend on the load characteristics, as for full load most of the time, high efficiency at heavy load would be desired, while for Plant

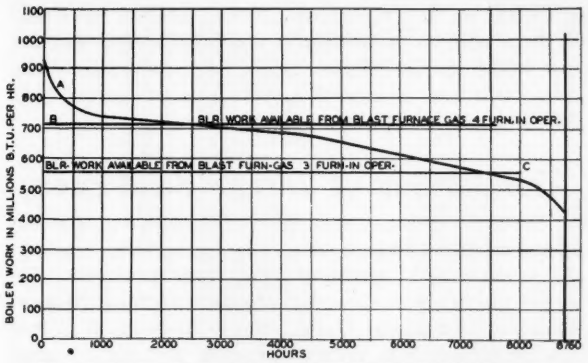

BOILER WORK IN MILLIONS B.T.U. PER HR.
HOURS
A
B
C
BLR. WORK AVAILABLE FROM BLAST FURNACE GAS 4 FURN. IN OPER.
BLR. WORK AVAILABLE FROM BLAST FURN-GAS 3 FURN-IN OPER.

FIG. 3. POWER REQUIRED FROM AUXILIARY FUEL

III, good efficiency at 45 to 55 per cent load is desirable, with inexpensive though less efficient equipment to carry the higher loads.

Gas Available

With blast furnaces, a considerable part of the top gas is available for boilers. American practice uses from 1500 to 3000 lb. of coke per ton of pig and gas for heating the blast should not exceed 20 to 25 per cent of the top gas, so that, for 450 lb. pressure, steam available would be 4500 to 10,800 lb. per ton of pig. After supplying miscellaneous needs, this should be sufficient for some 80 per cent of the mill power requirements. Even better results are obtainable as one plant has shown an average for 2 yr. of 3.67 lb. steam per pound of coke used in the blast furnaces and, for 4 mo., when all available gas was used for steam, 4.22 lb. of steam were made per pound of coke charged. About 0.79 lb. of steam per pound of coke was needed for the turbo-blowers.

Auxiliary Fuel

Because the supply of blast furnace gas is subject to interruption and a tendency to use it for metallurgical heating and for underfiring coke ovens, it is necessary to provide some auxiliary fuel supply, variable to meet power deficiency, even to the point of carrying the entire plant load for a short period. Figure 3 shows line A the load duration for a plant with four blast furnaces and lines B and C the power available when 4 and three furnaces are working. Values above these lines would be the power needed from auxiliary fuel for the respective conditions.

It is desirable that both fuels be burned in the same furnaces to avoid duplication, which practically limits the auxiliary fuel to pulverized form.

Earlier developments used pulverized fuel from the top and gas from the side of the furnace with manual control. More recent systems have coal and gas from opposite sides of the furnace as in Fig. 4 to avoid forcing of coal flame against the tubes by gas flame, when both are working. Also automatic control systems are used, coal feed coming on as required to meet gas deficiency.

Diagram of the control is as in Fig. 5. Gas pressure is maintained in the gas main at that needed in blast stoves by regulating flow to the furnace gas burner. All available gas will be used before any auxiliary fuel is fed. When available gas is insufficient to maintain steam pressure, the master controller starts the pulverized coal feeders, one at a time, four feeders to each boiler. As pressure rises, feeders are again cut out. Relay No. 1 prevents feeding more coal to any boiler than it can properly use with the induced draft fan running at full capacity, even when the master controller is increasing the capacity of other boilers.

As failure of the induced draft fan would result in excessive furnace pressure which would be dangerous for equipment and attendants, relay No. 2 shuts off the forced draft fan and gas supply and opens the auxiliary air inlet if the induced draft fan fails.

Furnace Arrangement

Because volume of products of combustion is large, power to produce draft becomes excessive at high boiler outputs, and it is found that, for good results, heat

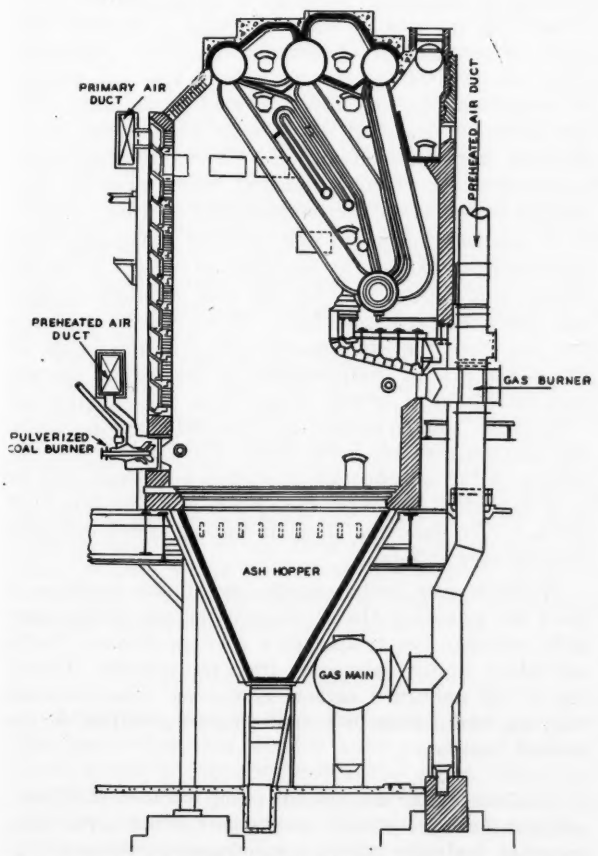


FIG. 4. BOILER UNIT FOR COMBINED GAS AND PULVERIZED COAL FIRING

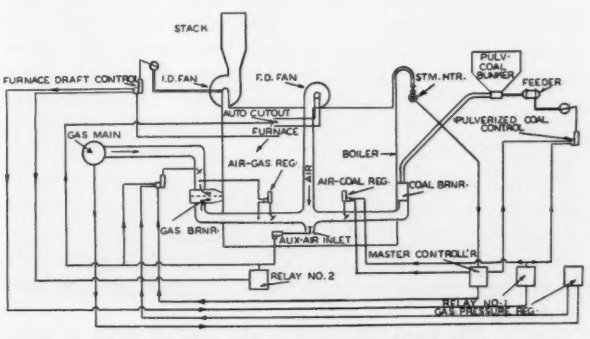


FIG. 5. AUTOMATIC CONTROL SYSTEM FOR COMBINATION GAS AND COAL FIRING

liberation should be limited to 20,000 B.t.u. per cu. ft. per hr. for the gas. As powdered coal can be handled at 25,000 B.t.u., this gives a slight excess volume when coal alone is used. With the low flame temperature of blast furnace gas, there is some possibility of trouble in maintaining combustion at low outputs, if completely water-cooled furnaces are used to permit very high rates of heat liberation.

Burner arrangement has been studied with the result that the one shown in Fig. 4 has given gratifying results. The two fuel streams should be kept out of contact until combustion has well progressed, say for 8 ft. from the tips of the burners, so that, if the distance between burner fronts is 16 ft., neither fuel combustion will be interfered with by the other.

Since demands for auxiliary fuel are sudden and irregular, the bunker storage system for pulverized fuel best meets requirements. Coke or breeze can be successfully pulverized in air swept ball or bar mills and burned in powdered form satisfactorily, with efficiency comparable with that for coal. This makes the two waste fuels, blast furnace gas and coke breeze available to generate all steam needed in one plant, taking full advantage of the diversity of mill load. Waste heat from open-hearth furnaces can generally better be used in air recuperators the heated air improving combustion conditions for the gas and coke.

Economics

Study of the efficiencies, auxiliary fuel requirements and cost of plant indicates that usually it is unprofitable to go above 450 lb. pressure where the blast furnace gas constitutes the main fuel supply. The investment is not justified by the saving in fuel cost.

Since waste fuel is used and, for a considerable part of the time an excess is available, use of air preheaters is seldom justified on economic grounds but other advantages may make it desirable. If excess power can be sold to neighboring plants or a public utility system, receipts from such sale may justify expenditure to secure higher efficiency.

Analysis of the cost of the regenerative heat cycle shows it to be no greater than for using steam from auxiliaries for feedwater heating. In addition it is automatic with no loss of steam due to lack of balance and supplying the small amount of make-up water from an evaporator avoids trouble from scale and dirt in the boilers. The regenerative cycle can be profitably applied to turbo-blowers for the blast furnaces and Bessemer converters as well as to the turbo-generators.

Use of electricity and compressed air for shears, hammers, pumping and the like eliminates the losses from distribution of steam over large areas, but steam at 100 to 150 lb. is necessary for process work at some points and its condensate cannot well be returned to the boilers. To avoid increasing the make-up, an evaporator, heated by live steam, may be used to generate the 150-lb. steam. If feedwater of good quality is obtainable, so that treatment cost is low, it may pay to expand live steam from 450 lb. through a turbo-generator unit to 150 lb., thus gaining a quantity of low-cost power but use of a reducing valve to cut down pressure is seldom justified.

As a side light, increase in the size of units is interesting: For boilers, from 5000 sq. ft. heating surface to 25,000 sq. ft.; for blowing, from engines of 40,000 cu. ft. a min. to turbo-blowers of 60,000 cu. ft. and one now building for 110,000 cu. ft.; for generator units, from 5000 rev. to 30,000 rev.; for mill motors, from 6000 hp. to 9000 hp. in a single motor.

The Burning of Various Solid Fuels

Interest in smokeless fuels has centered attention on the relative burning characteristics of cokes made by the various high- and low-temperature processes. Recently the Physical Chemistry Section of the Pittsburgh Experiment Station, United States Bureau of Mines, has published data on the time of burning of small particles of coal, semicoke, beehive coke, and charcoal under controllable conditions of furnace temperature, particle size and oxygen concentration. Work along this line is being continued on somewhat larger particles and on still other fuels.

Through the use of fuel particles weighing 4 milligrams it has been possible to follow the temperature of the particle throughout its burning. The maximum temperature of an individual particle burning in an excess of air at 800 deg. C. is, of course, much below the temperatures obtainable in a fuel bed.

The interesting part of the temperature curve of the burning, however, is the form the curve takes under different conditions. When the air temperature is 800 deg. C. the rate of rise of the particle temperature above the air temperature is so slow and variable that it is nearly impossible to assign a definite point as the "start" of ignition or active burning. Likewise, the point of completion of burning is often prolonged. With air at 1000 deg. C. the rate of rise and decline of temperature is very rapid. These effects vary with the nature of the fuel, being most pronounced for a material like electrode carbon. Therefore, strict comparisons of the burning times of many fuels by this method at the lower air temperatures are not possible.

It has been suggested that, given a sufficiently high temperature, the rate of burning of various forms of carbon will depend only on the rate at which oxygen can reach the carbon surface. There is some evidence for this from the experimental side. If this is so, as far as the rate of disappearance of the carbon dioxide goes, attention is drawn away from the question of "reactivity" of the carbon in a fuel bed where normally the temperatures are fairly high. The reactivity of the carbon as far as reduction of carbon goes, may still be very important—likewise the nature and disposition of the ash. In fact, the form of the ash from different fuels is very different.

Beehive coke under certain conditions produces a hard ash retaining almost the original size of the particle, whereas low temperature coke produces a fluffy ash which readily falls away from the particle. Covering of the unburned carbon by the ash from previous burning would seem to have an important effect on the rate of burning.

Alinement of centrifugal pump units with direct-connected motors should always be checked after shipment as bedplates often get sprung or distorted in transit.

Pneumatic coal conveying system is one of the most novel and interesting features of the new boiler plant of The Rudolph Wurlitzer Mfg. Co. Design and construction reflects the quality and refinement that characterizes their musical instruments.

KEEPING UP *with the demand for* ORGANS *and* RADIOS

INCREASED STEAM DEMANDS brought about by extensive additions to the organ, piano and radio cabinet departments made it imperative for The Rudolph Wurlitzer Mfg. Co. materially to increase the boiler capacity of their North Tonawanda, N. Y., Works. The first steam generating unit, a 4620-sq. ft., 250-lb. ga. Stirling boiler baffled for three passes and fired by either wood waste or pulverized coal, has just been completed and plans are under way for the installation of a duplicate unit.

Because of the limited space at the old plant and the fact that the hand fired h.r.t. boilers had outlived their usefulness, the decision to build a new plant rather than rebuild the old one was not difficult but the best location for the new plant was a different matter. The various factory buildings cover an area of some 10 acres and are so arranged that the new plant would have to be about 800 ft. from the center of steam demand if built where it could be on a railway siding or about 175 ft. from the nearest railroad siding available for coal unloading if built near center of load.

Pneumatic Coal Handling System

After due consideration, the second location, near the load center, was decided upon because it allowed better steam distribution without the added initial cost and heat losses of long underground steam lines. This decision brought about an interesting coal handling problem, complicated not only by the fact that coal must be carried a distance of some 175 ft. from the railroad siding but because the conveyor would have to pass over the piano finishing department, a building 42 ft. high, where an absolutely dustproof conveyor would be necessary.

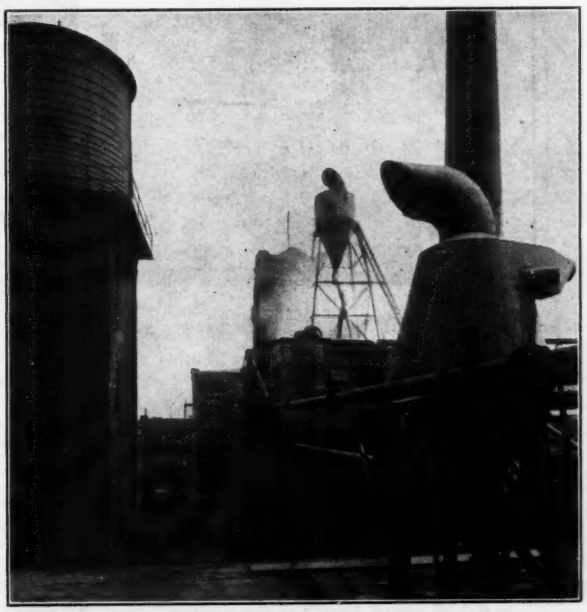


FIG. 1. ONE CORNER OF THE POWER PLANT SHOWING PARTS OF THE COAL HANDLING AND WOOD WASTE COLLECTING SYSTEM

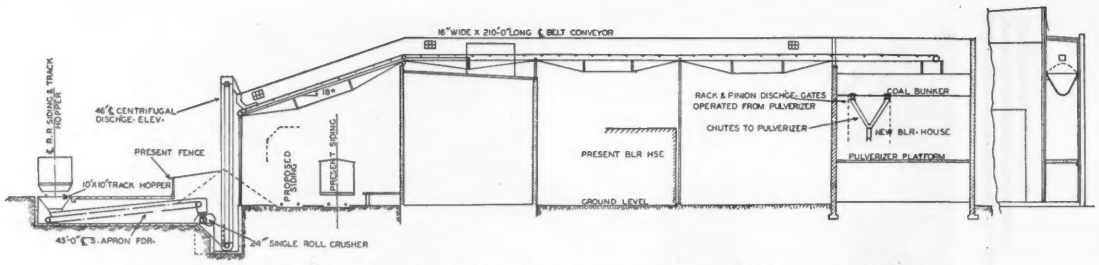


FIG. 2. THE BELT CONVEYOR ARRANGEMENT ORIGINALLY PLANNED

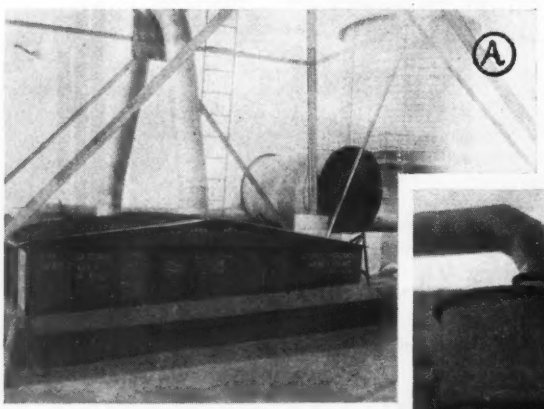


FIG. 3A. THE BLOWER EXHAUST SILENCER INSTALLED ON TOP OF THE POWER PLANT

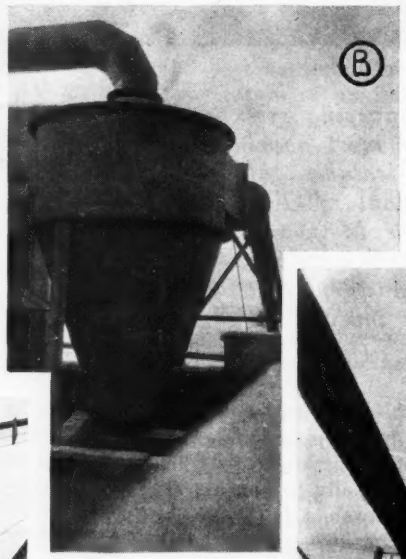
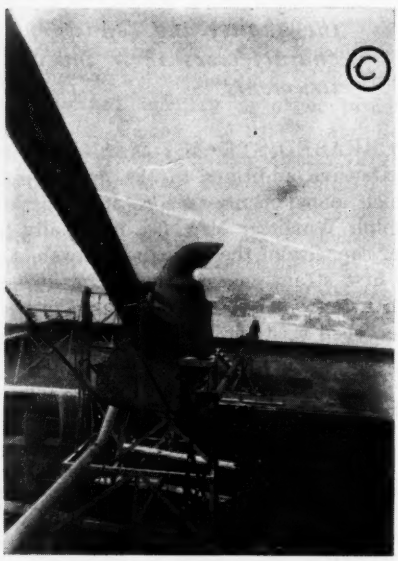


FIG. 3B. THE CYCLONE SEPARATOR

FIG. 3D. UNLOADING A CAR OF COAL

FIG. 3C. THE PIPE LINE COMING ACROSS THE TOP OF THE PIANO FINISHING DEPARTMENT



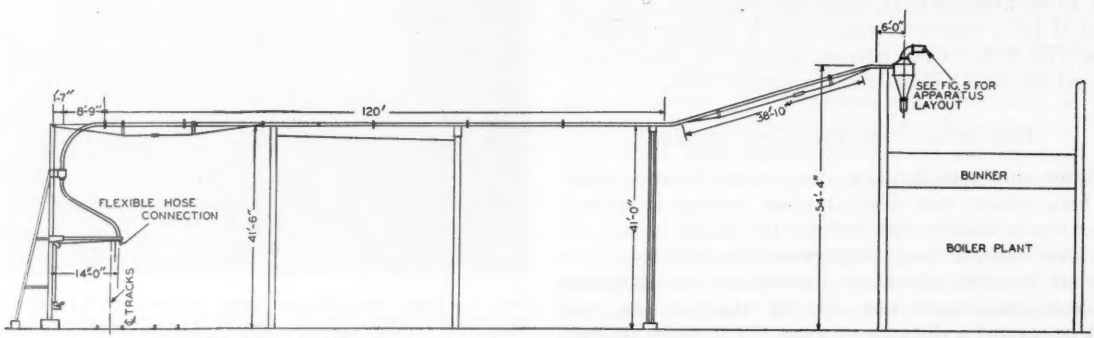


FIG. 4. GENERAL ARRANGEMENT OF THE PNEUMATIC HANDLING SYSTEM AS INSTALLED

At first a mechanical system such as shown in Fig 2 was considered. This consisted of a 10 by 10-ft. track hopper, a 45-ft. apron feeder discharging into a 24-in. single roll crusher, a bucket elevator lifting the coal 46 ft. to a 16-in. belt conveyor 210 ft. long for delivery to the hopper in the boiler room. Under normal conditions, this installation was estimated to cost $20,000. The track hopper and apron feeder would have required a concrete tunnel about 10 ft. square and 35 ft. long and in some parts 10 ft. below the ground surface where water and possibly quicksand would make the total cost problematical.

This arrangement was far from satisfactory and after a thorough investigation the Brady pneumatic system with a capacity of 15 t. per hr. was decided upon. In addition to dustless operation, which was an important factor, the savings in first cost over the original mechanical system was in the neighborhood of $10,000, the interest on which is sufficient to pay for the power and labor required to handle their annual coal supply.

General arrangements and details of this coal handling system are shown in Figs. 1, 3, 4 and 6. Fundamentally, the system consists of a nozzle at the railroad siding, a 7-in. pipe line to the power house, a centrifugal or cyclone separator, a vacuum chamber discharger, a scrubber to eliminate dust from the discharged air, a Roots exhauster driven by a 75-hp. motor and a silencer through which the air is discharged.

Coal Storage Provided

Coal received by car can be unloaded direct to the boiler plant as shown in the close up of the nozzle in Fig. 3D or it can be dumped on the track and stored by means of the portable conveyor shown back of the car in the same photograph. When reclaiming stored coal, it is taken directly from the pile through an extension pipe line and to the nozzle just as when cars are unloaded direct. A 14-ft. swinging boom and about 20 ft. of flexible hose gives the nozzle an operating radius of well over 25 ft. either from the ground or car.

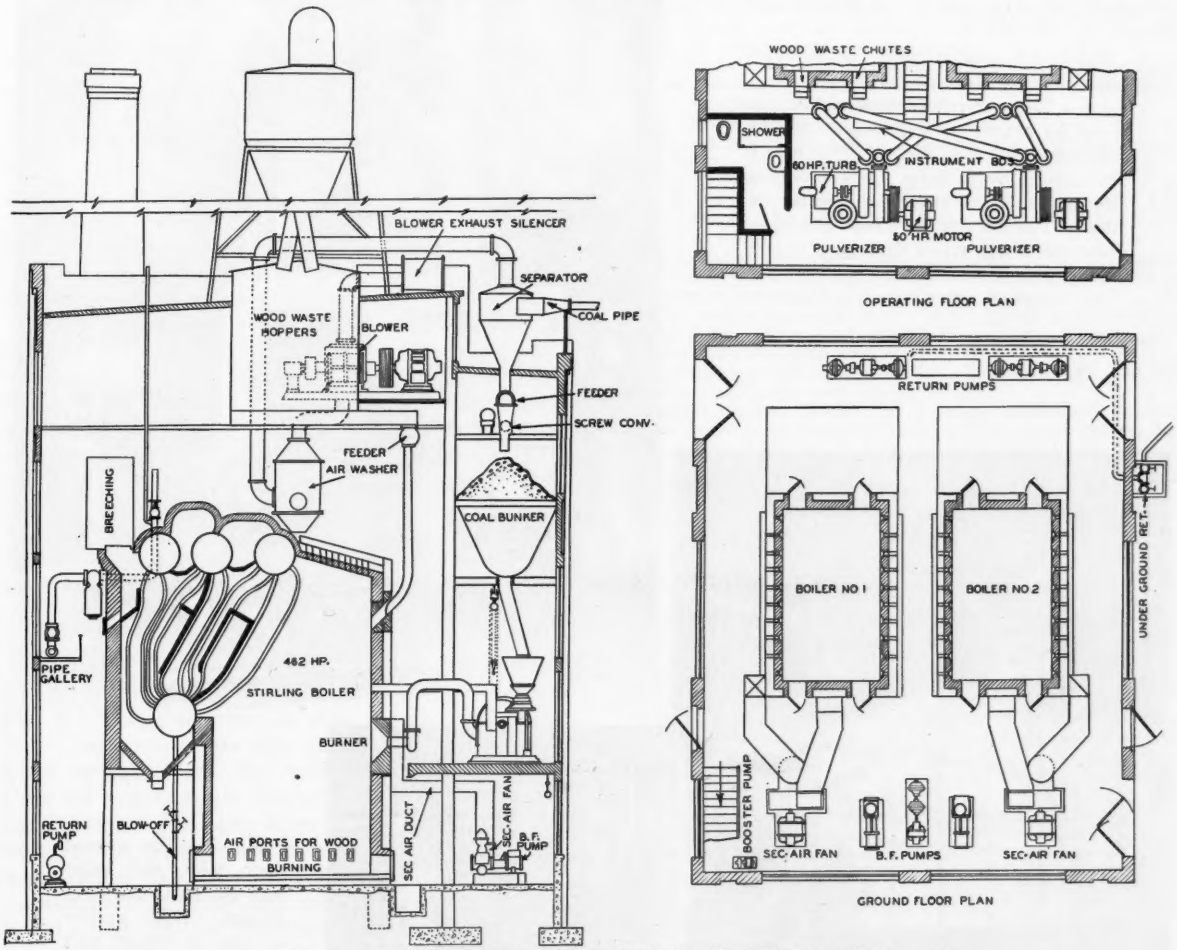


FIG. 5. PLAN AND CROSS SECTION OF THE BOILER HOUSE

From the nozzle, the coal is carried through the 7 in. pipe line, shown in Figs. 4 and 8, over the piano finishing department and into the centrifugal separator, Fig. 3B. Here the heavier coal particles drop to the bottom from which they are discharged through a 16 by 16-in. air-tight rotary discharger to a 12-in. screw conveyor which distributes the coal to the 75-t. bunker. Details of this arrangement are shown in Fig. 5. The feeder and screw conveyor is driven by a General Electric 5-hp. motor through a Foote speed reducer.

Air and some fine dust pass out the top of the cyclone to the top of a scrubber provided with water

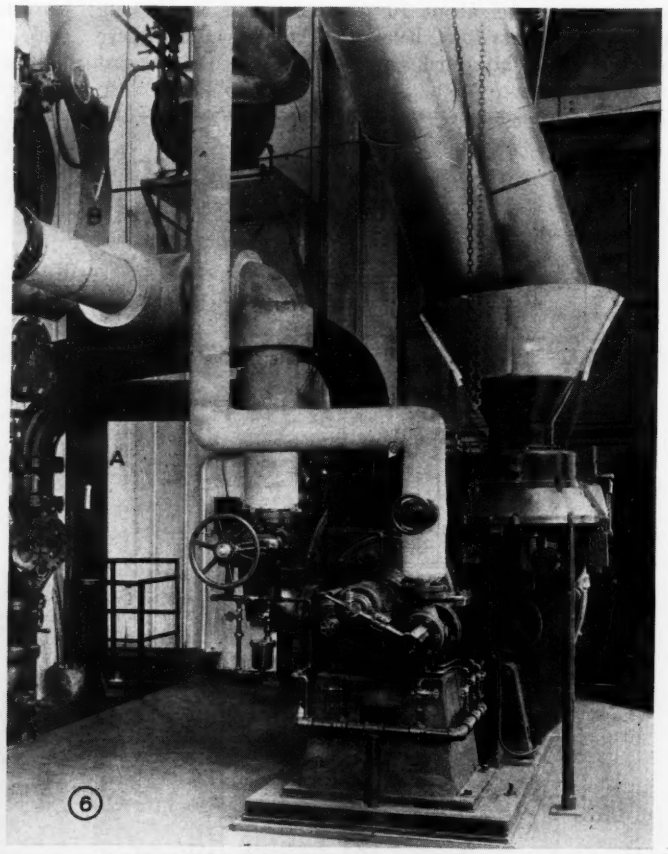
sprays and filtering material. Dust separated from the air by the water is washed down to a sludge tank from which the coal is reclaimed and the water drained to the sewer. The air then goes to the 16 by 28-in. Roots exhauster, driven through a v-belt drive by a 75-hp. motor, and is discharged through the muffler on the roof, Fig. 3A, to the atmosphere. The pipe line, cyclone and silencer are also visible in Fig. 1, while the arrangement inside of the plant is well shown by Fig. 5. As the exhauster is installed above the boiler, it is set on a Korfund base to deaden vibration.

At present, the pneumatic system handles only the coal but the company is considering connecting into it the ash handling system and a general vacuum cleaning system for the boiler plant. This can be accomplished with little additional cost using the same exhaust and air filtering equipment.

Entire Plant Reflects Care in Design and Construction

This is, of course, but one of the interesting features of the plant, the entire design of which reflects the same care and thoroughness of design and finish that has made the Wurlitzer organ a household word throughout the world. C. N. Deverall, a gifted musician and chief engineer of the Rudolph Wurlitzer Co., was at one time superintendent of the organ department and it is perhaps but natural that his training there in building the finest that could be built with the best materials to be obtained should be apparent in the new plant to

Pulverized coal is used for auxiliary firing at the Rudolph Wurlitzer plant. From a 75-ton overhead bunker, this coal is fed by gravity to the 4500 lb. per hr. pulverizer shown in Fig. 6. This unit is dual driven by a 60-hp. turbine on one side and a 50-hp. electric motor on the other. The turbine is direct connected while the motor drives through a V-belt.



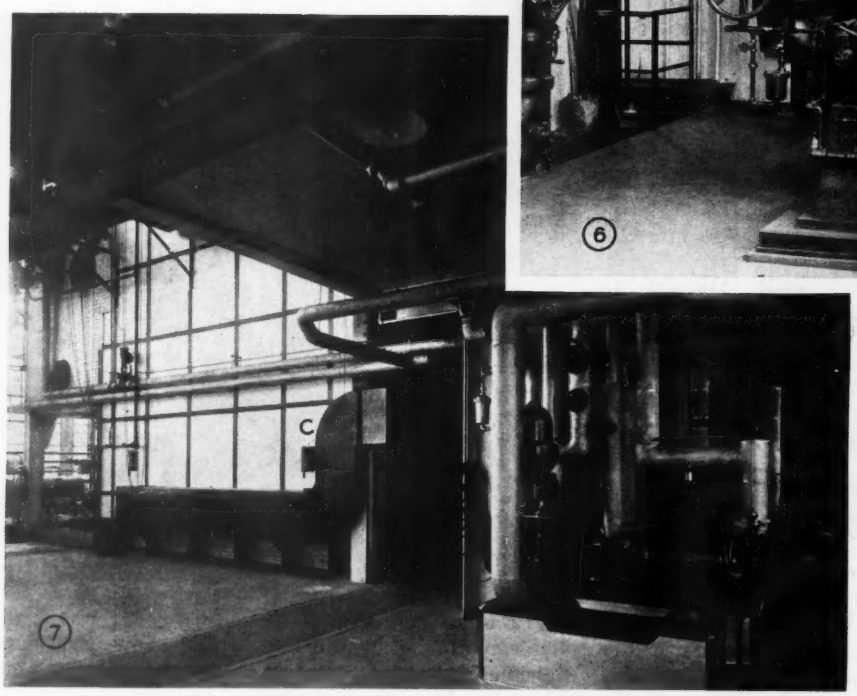


Fig. 7. The ground floor with the boiler feed pumps in the foreground. Note, system of ducts on furnace wall through which air is carried to the furnace when burning wood waste.

which he gave so much time and attention. The plant was designed by Mr. Deverall and Geo. H. Paddington, consulting engineer. C. S. Gladden, director, power and maintenance section of the General Motors Corp., supplied a great deal of valuable data used in the design of the wood burner features of the furnace and it might be added that the success of this furnace as a wood burner reflects great credit on him.

The plant itself, a corner of which is shown in Fig. 1, is designed for two boiler units although only one is installed at present. The unit installed is a 4620-sq. ft. Stirling boiler baffled for three passes with a 3228-cu. ft. air-cooled furnace designed to burn either wood waste or pulverized coal.

The design of the furnace with a Bigelow suspended arch provides for the collection of heated air at the top of vertical air ducts in the walls. This air is brought down through the duct A in Fig 6 to the suction of a Buffalo fan driven by a Louis Allis 20-hp., two-speed, slip ring motor. When burning wood waste, this fan discharges the air through the steel ducts C of Fig 7, to small tapered ports near the bottom of the furnace so that the air impinges at high velocity on the floor of the furnace. When burning coal, the secondary air is admitted around the coal burner.

Wood waste from various parts of the factory are collected in the cyclone on top of the boiler plant, Fig. 1, and are discharged by gravity to a 2000-cu. ft. wood storage provided above the boiler. Plans are also under way for a wood storage silo for surplus. From this the wood waste would be reclaimed and delivered to the overhead storage space by a small fan driven, probably, by a 7½-hp. motor. From the storage space, the wood waste is fired by a Hofft wood stoker driven by a 3-hp. Westinghouse motor through a Reeves transmission automatically controlled.

Pulverized Coal Is Used for Auxiliary Firing

From the 75-t. overhead bunker, this coal is fed by gravity to the 4500-lb. per hr. Riley Atrita shown in Fig. 6. This pulverizer is dual driven by a 60-hp. Moore turbine on one side and a Louis Allis 50-hp. motor on the other. The turbine is direct connected while the motor drives through a v-belt. At present, this pulverizer feeds one Riley burner but as shown in the plan, Fig. 5, the final installation will be piped up so that either pulverizer can feed either boiler.

Secondary air fans and boiler feed pumps are installed on the ground floor immediately below the pulverizers, one fan and one boiler feed pump for each unit with cross connections for emergency operation. The boiler feed pumps are Cameron 10 by 7 by 13-in. direct acting simplex steam pumps. A Westco-Chippewa 2 stage centrifugal pump with a capacity of 75 g.p.m. against a 380-ft. head and driven at 1450 r.p.m. by a General Electric 15-hp. motor is provided for standby boiler feed and general service.

Returns from the heating system are handled by four Nash size E-25 vacuum return pumps running at 1450 r.p.m. Three pumps operate continuously while the fourth pump operates intermittently, being controlled by a float valve in the receiver. On light loads, two of these pumps are shut down. Each pump is dual driven by a 7½-hp. Carling turbine and a General Electric 7½-hp. motor, the turbine being on the outboard side and driving the pump and motor through a Hilliard clutch.

All auxiliaries are dual drive in order to give close regulation of the exhaust steam during the summer months when there is no heating load. All electric power is purchased and coming from Niagara Falls is, of course, 25-cycle. All motors in the boiler plant are for 440-v. 3 ph. 25-cycle. In the mill, frequency changers are utilized to obtain the 60 and 125-cycle current needed for the high speed motors of the wood working machines.

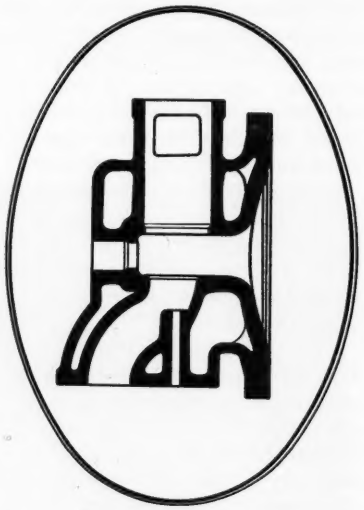
The wood waste and dust collecting system installed in the new radio cabinet building is particularly interesting and will be described in an article by Mr. Deverall in an early issue.

Present Equipment in the Rudolph Wurlitzer Boiler Plant

1 Babcock & Wilcox 4620-sq. ft. Stirling boiler, baffled for 3 passes with a furnace volume of 3228 cu. ft. and designed for wood waste pulverized coal firing.
1 Riley Stoker Co. 4500-lb. per hr., Atrita driven by a Moore Steam Turbine Co. 60-hp. turbine and a Louis Allis 50-hp. 440-v., 3-phase, 25-cycle motor.
1 Riley Stoker Co. flare type burner.
1 General Electric Co. 110-v., 2.75-amp. shunt wound exciter for the magnetic separator on the pulverizer feeder.
1 Buffalo Forge Co. size 5½ Turbo-conoidal secondary air fan driven by a Louis Allis Co. type B 20-hp., 1450/750-r.p.m., 440-v., 3-phase, 25-cycle motor with a Union Electric Mfg. Co. starter.
1 Bailey Meter Co. boiler panel consisting of air flow-steam flow meter, pressure gage and 3 pointer draft gage indicating pressure of secondary air, uptake and furnace.
1 M. A. Hofft Co. wood waste stoker, driven by a Westinghouse 3-hp., 1400-r.p.m., 440-v., 25-cycle motor through a Reeves variable speed transmission.
2 Ingersoll-Rand Co. 10 by 17 by 13-in. Cameron Simplex direct acting boiler feed pumps.
1 Westco-Chippewa Pump Co. 2 stage centrifugal standby boiler feed pump with a capacity of 75 g.p.m. against 380 feet head and driven at 1400 r.p.m. by a General Electric 440-v., 25-cycle, 15-hp. motor.
1 Cochrane Corp. steam separator.
1 Ranarex CO_2 recorder.
2 Nash Engineering Co. size E-25 vacuum return pumps running at 1430 r.p.m., each dual driven by a Carling Turbine Co. 7½-hp. steam turbine and a General Electric 7½-hp. motor with a Hilliard Corp. clutch used between the turbine and motor.
1 P. H. & F. M. Roots Co. 16 by 28-in No. 5 exhauster driven by a General Electric Co. 75-hp., 730-r.p.m., 440-v. motor, exhauster mounted on a Korfund base.
1 Brady Conveyors Co. 12 in. through conveyor cyclone discharger driven by a General Electric 5-hp., 710-r.p.m. motor through a Foote Bros. Gear & Machine Co. speed reducer.

Blowoff valves ..... Yarnall-Waring Co.
Observation Doors ..... Riley Stoker Co.
Walls and suspended arches ..... Bigelow-Liptak Co.
Feedwater regulators ..... Bailey Meter Co.
Safety valves ..... Consolidated Ashcroft Hancock Co.
Boiler stop and check valves ..... Golden Anderson Co
Soot blowers ..... Diamond Power Specialty Co.
Exhaust head ..... Swartwout Co.
Damper regulator ..... Ruggles-Klingemann Co.
Back pressure valves ..... Klipfel
Chain blocks ..... Morris Machine Co.
Valves and piping ..... Lunkenheimer-Crane
Steam traps ..... Armstrong Machine Works
Check valves ..... Lunkenheimer Co.
Pressure gages ..... Federal Gage Co.
Pipe covering ..... Johns-Mansville
Wood waste and dust collecting system ..... Kirk & Blum
Pneumatic coal conveying system complete ..... Brady Conveyors Co.
Machine insulation ..... Korfund Co.
Boiler setting ..... Wm. Summerhays Co.

DIESEL ENGINE UPKEEP



PART V. COOLING WATER MAINTENANCE. METHODS OF REDUCING HEAT STRAINS. PRECAUTIONS IN STOPPING ENGINE. METHODS OF CLEANING JACKETS. REMOVAL OF SCALE AND SEDIMENT. TESTING METHODS

COOLING WATER maintenance for Diesel engines involves not only the securing of a proper quality and quantity of supply either by initial selection or by subsequent treatment but it also requires constant attention to securing proper flow and temperature of that water. Fundamental cooling system troubles are caused usually by deposits of dirt, oil or scale, or by corrosion.

Cylinders are now usually supplied with liners: therefore there is provision for expansion and contraction due to heat change but cylinder heads are of fairly rigid box section, hence, for safety, they should be maintained at as uniform temperature as possible. As far as heat strains are concerned, the degree of temperature makes little difference; it is the difference in temperature between the inner and outer portions of the section that causes unequal expansion, hence strains, if not fracture. With temperatures as high as 3000-deg. F. inside the cylinder and comparatively cold water outside, it is inherent that strains should be set up by unequal expansion.

Wide variation of temperature of the metal walls of piston, cylinder and cylinder head are shown in Fig. 1, which represents the results of tests made by Sulzer Bros. These temperatures apply only to the particular type of engine tested and the manner of operating it, otherwise these temperatures are merely suggestive.

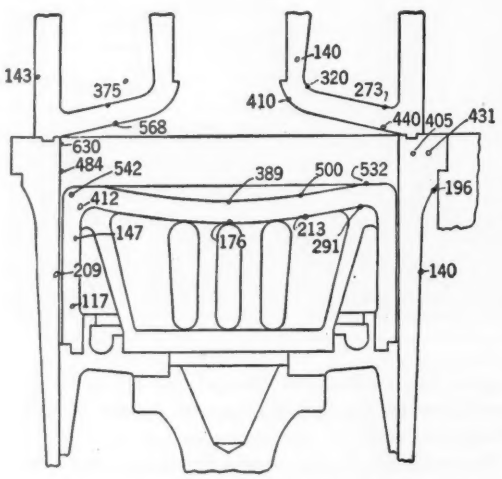


FIG. 1. RECORDED FAHRENHEIT TEMPERATURES OF A 4-CYLINDER, 1350-HP. DIESEL ENGINE, WITH COOLED PISTON AT FULL LOAD. THE SMALL CIRCLES REPRESENT THE LOCATIONS OF THE THERMOCOUPLES

SYMMETRICAL CONSTRUCTION REDUCES BREAKAGE

Nearly 35 per cent of the heat produced in an internal combustion engine cylinder is carried away by the cooling water and most of this heat passes through the cylinder head. It is because of these facts that the very irregular shaped cylinder heads of past years have given way to the more symmetrical shapes of today. It is because of this also that it is far better to circulate a large amount of warm water than a small amount of cold water. More rapid circulation results in more uniform temperature throughout the head. Recirculation of this kind is done by passing a part of the discharge back to the suction side of the pump.

VERY LOW INLET WATER TEMPERATURE UNDESIRABLE

Temperature of inlet water under 50 deg. F. is not so desirable as a temperature of about 65 deg. When scale forming or sea water is used, the discharge temperature should not exceed 100 deg. When the cooling water is reasonably pure, the discharge temperature may be raised to 140 deg., at which temperature the finger barely can be held in it. Enough water should be circulated to keep the difference in temperature, between that entering the engine and that leaving the cylinder head, at not exceeding 40 deg. The accompanying table shows the approximate quantity of cooling water required under different temperature conditions.

QUANTITY OF WATER PER HORSEPOWER-HOUR

Inlet Temp. Deg. F.	Discharge Temp. Deg. F.	
	140	110
50	4 gal.	6 gal.
60	4½ "	7¼ "
70	5¼ "	9 "
80	6 "	12 "
90	7¼ "	18 "

For general circulation, the water pressure should be sufficient to produce the required flow through the jackets. The pressure at the engine room floor level should be not less than 15 lb.

Excessive cooling is dangerous as it will cool the cylinders too much, causing them to contract while the piston, being hot, will expand, resulting in piston seizure. Care should be used to adjust the supply of cooling water to the engine's needs. If through some cause, the cooling water should attain a high temperature of,

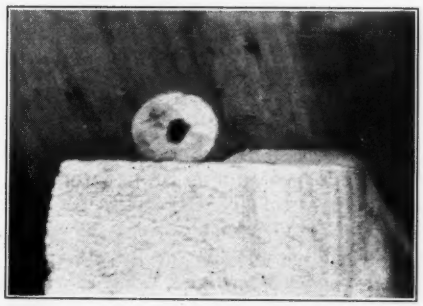


FIG. 2. SCALE DEPOSITED FROM CITY WATER ALMOST FILLS PIPE. PIPE WITH SCALE IS SHOWN RESTING ON CONCRETE PIER

say, 200 deg., large quantities of cold water should not be admitted suddenly as this also will cause piston seizure.

Engine Should Be Cooled Slowly After Stopping

After stopping the engine, the cooling water should be throttled down gradually but kept circulating for about 10 min. at a reduced rate sufficient to keep the discharge water temperature about the same as when running. Sudden cutting off of water circulation might cause cracking of cylinder or cylinder head as the heat stored in the piston, cylinder and cylinder head is sufficient to bring the water to the boiling point. Moreover, at the higher temperature, scale may form from water that would not deposit it at normal operating temperature. Such abnormal rise in temperature also would cause the lubricant to dry and carbonize.

Temperature of discharge does not have any constant relation to that of the inner and outer surface of the liner. This is affected by the velocity and turbulence of the water and the cleanness of the surface. An engine should be cooled just sufficiently to prevent carbonizing the lubricating oil and depositing scale. Velocity and uninterrupted flow are extremely important to proper circulation; a short stoppage of flow may result in a fractured part; retarded flow or stagnation at certain points will result in increased tendency to precipitate salts and foreign matter from the water.

Circulation Prevented by Air and Steam Pockets

Air and steam pockets, if formed, will impede or even prevent circulation. If such pockets exist, they can be detected usually by hot spots in the cylinders. These hot spots may shift from space to space. Pockets are always found in the high parts of the jackets; what little water may reach them will be turned into steam. Trouble with pockets may be remedied by fitting small pet-cocks in these high parts and opening the cocks occasionally. Pockets will be avoided if the hot water is discharged from the highest point in each element of the jacket system to the lowest point in the next jacket element to be cooled. This is proper water circulation procedure.

Exhaust valve cooling is important since this part is subject to intense heat and to the exhaust flame. Warping of the valve and its stem and scoring of the valve and seat result from inattention to proper cooling. Exhaust pipes should be water jacketed. Fires have occurred, due to oil, which has leaked out of the fuel lines, striking a red-hot exhaust pipe. Warming up a cold engine before starting it is advantageous in avoiding sudden temperature changes and heat strains and in making starting easier in cold weather. For this purpose, the discharge water from another engine that is running, or steam, if it is available, may be used.

Oil as Cooling Medium

Oil is used for piston cooling because, in its use, there is no danger from salt incrustation and any leakage into the crankcase will not cause trouble with emulsions but less heat is carried off for a given rate of flow than would be the case with water. If the oil is permitted to get too hot, a layer of carbon, which will prevent heat transference, will be formed on the jacket walls. Oil should not leave the piston at a temperature above 140 deg. F.

If a certain cylinder or head becomes hot, indicating insufficient water circulation, the water inlet to that

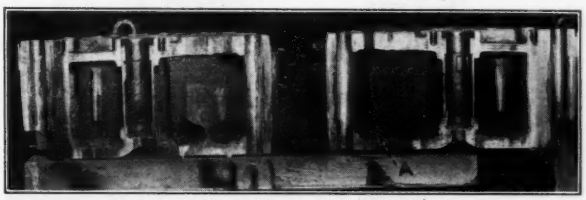


FIG. 3. TWO HALVES OF A LARGE CYLINDER HEAD THAT CRACKED BECAUSE OF DEPOSITS OF SCALE AND SEDIMENT

cylinder should be disconnected and the pump started to see if the delivery is clear. If the fault is not here, stop the pump and connect the water inlet and disconnect the discharge from the cylinder head. If there is no free flow when the pump is started again it will be necessary to clean out the jacket.

Cooling Effect Regulated by Recirculation

All cylinders should receive the same cooling effect with the valves to the cylinder jackets wide open. Slight changes in the quantity of water supplied to each cylinder can be adjusted by the valves but none of the valves should be throttled down much as this reduces the velocity of flow. It is better to maintain constant velocity by recirculating part of the warm water from the outlet back through the suction of the cooling water pump.

If the water discharge temperature drops considerably, the pump is running too fast for the particular speed and load of the engine. There is a certain temperature at which an engine will run best. The pump should be so regulated that the cylinders are kept at

this temperature. The fuel economy of a cold engine is lower than that of a properly warmed one due to failure to consume the fuel properly and to excessive heat losses to the cooling water.

Circulating Pumps

For small plants without overhead tank supply, the most approved type of circulating pump is either an outside packed triplex pump or a horizontal plunger pump. Without the protection of an overhead water supply, the loss of pump suction, which is liable to occur to a centrifugal pump, is dangerous. With this protection, the motor-driven centrifugal pump is most satisfactory, especially in large plants. Duplicate pump installation for a single engine and interconnection of pumps, where several engines are installed, are valuable safeguards.

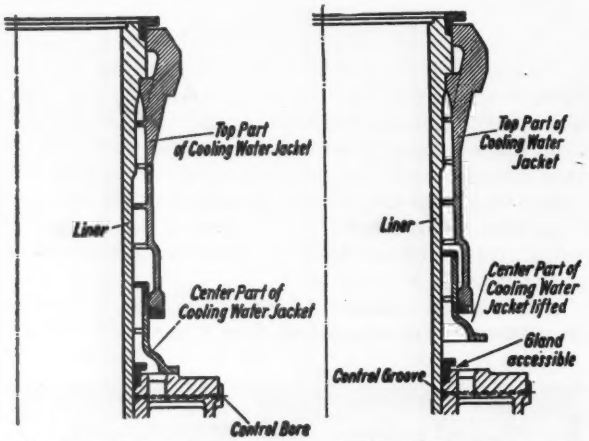


FIG. 4. ACCESSIBILITY OF CYLINDER LINER GLANDS IN AN EUROPEAN BUILT DIESEL

Pumps should be installed with the suction line as short as possible. Discharge to an overhead tank should be made by running the pipe to the top of the tank rather than to enter it at the bottom. This makes the discharge head constant and avoids the possibility of emptying the entire tank in case of pump suction valve leakage. A bypass line from the bottom of the tank can be run into the pump discharge for priming purposes.

Water jackets must be kept free from mud and scale, otherwise, effective cooling is impossible with any quantity of water. All water circulating systems should have strainers connected in the line; the duplex type which clean without disturbing operation, are most convenient.

Very little scale is enough to do harm because of overheating of the cylinder walls and consequent breaking down of their lubrication. Scale forms most readily at the hottest places. Sediment is precipitated more freely at restricted areas and places where velocity of the flow is decreased suddenly or direction of flow decidedly changed. A glance at the head shown in the headpiece of this article is sufficient to indicate where trouble is liable to occur due to deposits. Because vertical engines may be fitted more easily with more symmetrical heads having larger jacket area, preference is generally given to this type over the horizontal type for large engines.

Removal from the water of all scale forming ingredients before it reaches the engine is a much better way to solve the scale problem than to remove the scale after it has formed in the jacket. All water intended for cooling should be tested to determine the most effective method of softening, therefore, before it is applied to an engine. There is no one method which will fulfill all conditions.

Incrusting ability of some waters is illustrated in Fig. 2, which shows how water from a city main filled a pipe with scale and Fig. 3, which shows the deposit found in a cylinder head after it had cracked and was sawed in two for examination. It will be noted that at A, which is diametrically opposite the cooling-water inlet and directly under the restricted outlet opening, the water space is almost completely choked by a mass of sediment and scale.

Jacket Cleaning Methods

Periodical and thorough cleaning of all water jackets should be routine procedure. Mud and sand, if they have been permitted to enter the jacket, may be removed by washing out with a strong stream of water. Scale is removed either by scraping or by filling the jackets for several hours with muriatic acid, of which a 10 to 50 per cent solution is used as required. Effervescence is apparent while the scale is being removed. After the effervescence ceases, which is an indication that all scale has been removed, it is well to add some more solution and if no further action is observed, scale removal may be regarded as complete. The jacket should then be washed out by a rapid circulation of water. If the acid solution was strong, it is well to follow the water washing with a rinsing with a strong soda or lye solution and then follow with fresh water. Some follow the first water washing with a hot water application and then with a final cold water application.

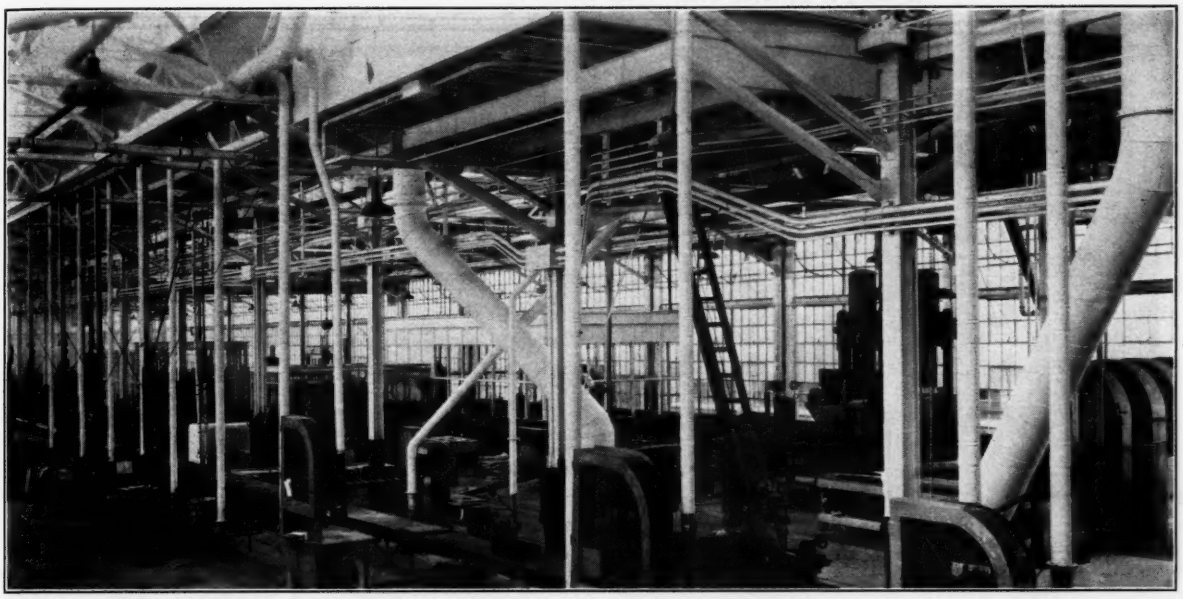
Mixing the acid and lye solutions may best be done in a barrel and the solutions circulated through the jackets, after disconnecting the jacket piping to the cylinder, by use of a hand pump. If steam is available, stick a steam hose into the acid solution and keep it near the boiler point until no further evidence of activity is apparent.

Corrosion may be caused by acidity of the water and its action increased by aeration. A simple test for acidity is to drain some of the cooling water into a clean bottle and immerse a piece of polished brass or copper in this drained liquid. The bottle is then set aside in a warm place and if the metal is not tarnished in 24 hr. there need be no fear from acid action.

It is now felt that with a cooling water practically oxygen free throughout the cooling circuit there will be little effect of corrosion on the repair bills of Diesel engines.

Open discharge funnels, where active churning of the water produces aeration, although offering the convenience of observing the temperature of the discharge water by touch of the hand, are now being looked upon with disapproval. Temperatures are now observed more accurately by means of thermometers, and alarm systems are now installed as further protection.

Engine builders usually supply some means for inspection of water jackets. Accessibility of liner glands of a European engine is illustrated in Fig. 4. Plates are often provided to cover the holes in the cylinder head jacket through which the core was removed after casting.



Interior Wiring of *Industrial Plant and Mill Buildings*

By W. Wendelken

Supervisor of Lighting
Westinghouse Electric & Mfg. Co.

WIRING OF industrial plants and mill buildings presents a problem which is usually different from the ordinary class of wiring found in residences, office buildings, or the like. Floor areas are usually large and in the case of mill buildings, as a general rule, single-story structures are encountered. Multi-story industrial or manufacturing buildings also call for considerable ingenuity to provide suitable wiring installations to meet all demands.

In both classes of buildings, connected motor and lighting loads are usually found to be heavy and varied over the entire floor space. Machine tool motors of all sizes and in all possible locations are scattered over the floor area and in large mill buildings the lighting load is also found to be heavy as the ceilings are high and lights are hung high to clear cranes. Foot candle intensities have to be increased to make up for the increased depreciation due to smoke, dirt, or fumes, and a proper lighting system will often require from 2 to 4 w. per sq. ft., which generally means the use of high mounting 1000-w. units.

Any wiring system, therefore, for the foregoing purposes has to be extremely flexible to meet the constant changes and additions to equipment as floor layouts are arranged, be able to supply lighting or power to any point on the floor area, prevent expensive shut-downs of machinery and do so at a minimum first cost and later maintenance cost, and at the same time present an appearance that does credit to the building within which it is installed. To accomplish all of this is not easy and, although no claims are made for the schemes outlined herein as being ideal, it is believed that they may be of help to those who are seeking a good job of shop wiring. The information and suggestions as given in the following paragraphs and cuts describe very closely a typical scheme of wiring as used throughout the plant of a large manufacturing concern, manufacturing varieties of electric equipment. No conduit, wire or switch sizes have been indicated; these are a matter of connected horsepower load the wiring serves, left to the judgment of the engineer in charge.

In Fig. 1, a typical plan of a single story mill or industrial building is shown to give an illustration of the way the secondary feeders and transformers are arranged. As a source of primary power to the feeder transformer stations, it has been found advisable to feed them with 2300 v. The supply is brought from the main distributing switchboard where the source of power is obtained and where suitable protective devices for each transformer station are provided. The use of the higher voltage ranges for transmission purposes throughout the works or plant is most suitable, especially where the area served is large or the transformer stations are located at remote points from the supply source. The scheme as employed in Fig. 1 consists of locating the transformer stations in the center of the buildings at

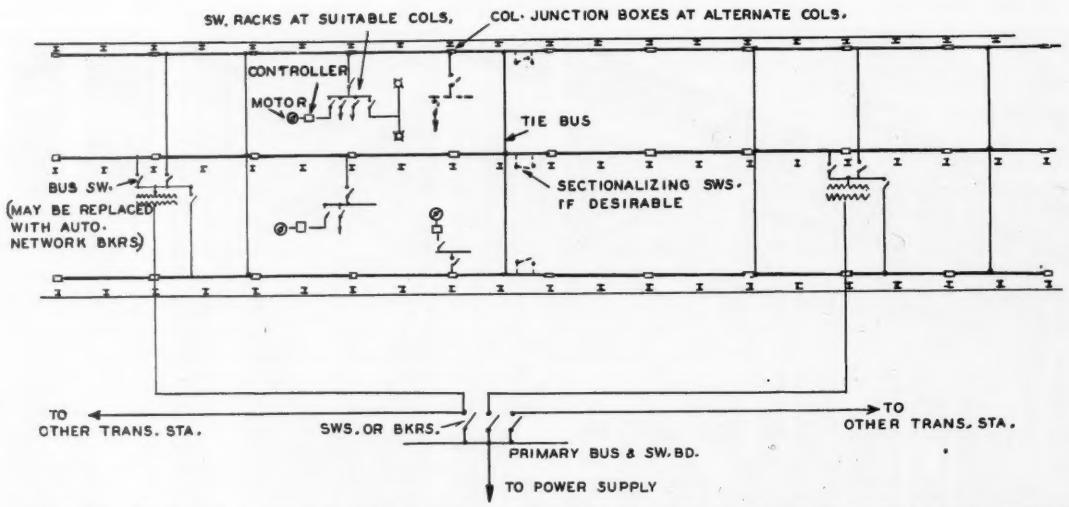


FIG. 1. TYPICAL PLAN OF A SINGLE STORY MILL OR INDUSTRIAL BUILDING ILLUSTRATING ARRANGEMENT OF FEEDERS AND TRANSFORMERS

intervals of 12 to 14 bays, this, of course, being dependent on the size of the load. The transformation is from 2300-v., 3-phase, 60-cycle to a 207/120-v., 3-phase, 60-cycle, four-wire grounded central system.

Transformer Connections

Transformers are connected as shown in Fig. 12. As this system has proved so popular and efficient with power companies for distribution, it was decided to try a similar scheme for industrial use, excellent results being obtained from all angles after installation. The system provided 3-phase power and lighting service from four wires and offers considerable savings in copper and also eliminates the need of separate lighting transformer stations with their attendant installation and maintenance cost.

Little if any trouble is encountered with the lower power voltage; and higher voltage lamps are, of course, as easily obtainable as the lower ratings. As shown in Fig. 1, the bus or main feeder system consists of conduits carried along each row of columns about 12 ft. 0 in. from the floor with large junction boxes placed at alternate columns for tapping in floor circuits when desired. It will also be noted that tie buses are located at several points throughout the aisle to equalize the load on the different buses forming the familiar grid or network system. A main feed from the transformer is carried through suitable fused switches to each of the column buses.

Use of Sectionalizing Switches

Sectionalizing switches may also be installed in the buses to segregate transformer stations in case trouble should be experienced on any of the main column buses. Trouble is very rare but in order to prevent shutdown of the whole floor, the installation of these switches may be found desirable. The scheme as outlined, however, in Fig. 1 has been in operation for several years in a number of large buildings and no trouble has ever been experienced from bus failure.

Although, probably contrary to general opinion, the use of conduit is strongly recommended for main buses and though the first cost may appear to be excessive, the final cost due to lessened maintenance is cheaper. There is, of course, no comparison between the appearance of an open wired bus and a conduit bus. The conduit system presents an appearance which cannot be equaled by any form of open wiring.

In order to provide branch power to machines on the floor, branch feeders are brought down the columns from the junction boxes overhead into column feeder switches, which are located at alternate columns or farther apart as the load indicates, and then fed through smaller switches out to the machines. These switches are built up into the form of a rack on a pipe or structural frame as shown in Fig. 13. A switch is located here to protect each motor and the larger switches, of course, serve as protection and disconnects for the whole rack. As the four a.c. power and lighting lines are

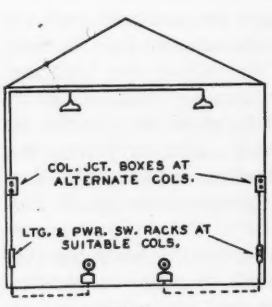


FIG. 2

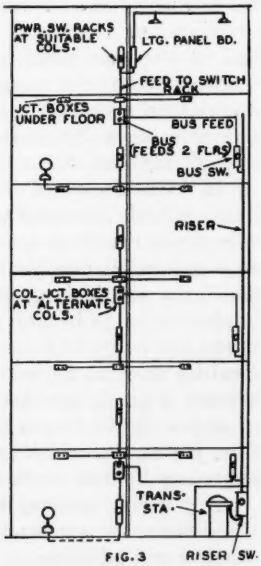
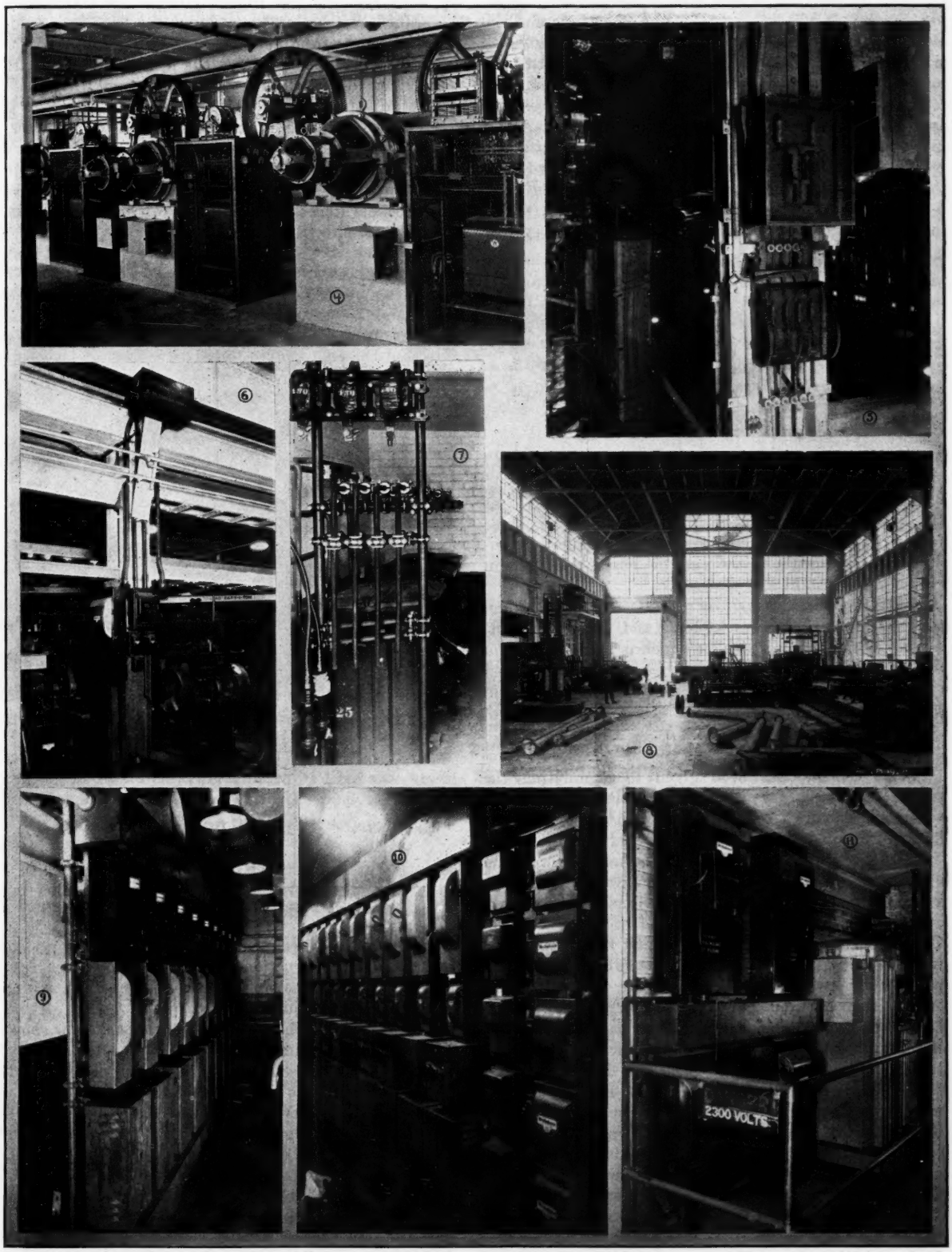


FIG. 3

FIG. 2. SECTION OF ONE-STORY BUILDING WIRING TO OVERHEAD LAMPS AND ARRANGEMENT OF JUNCTION BOXES

FIG. 3. MULTI-STORY INDUSTRIAL SHOWING DISTRIBUTION SYSTEM



FIGS. 4-11. VIEWS IN INDUSTRIAL BUILDINGS OF VARIOUS TYPES SHOWING METHODS OF WIRING AND INSTALLING SWITCHES

brought down to the rack, small 30-amp. switches are installed on the rack to take care of the overhead lighting system. It will be noted that the large junction box overhead is partitioned into two sections, also the junction box in the center of the switch rack is constructed to provide a separate compartment for a.c. and d.c. sources of power. The d.c. voltage in this case is 250 and is distributed along and down the columns similar to the a.c. system. The d.c. distribution circuits are brought from the main distribution switchboard and tied into the d.c. buses at various points along the aisle usually where the a.c. transformers are located. It is to be understood, of course, that the d.c. bus system

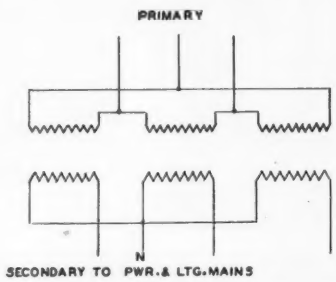


FIG. 12. TRANSFORMER CONNECTIONS WHICH HAVE BEEN FOUND SATISFACTORY

follows in general very closely to the a.c. system. Conduit is used for the buses and tie buses, and column switches are installed as shown.

Outgoing branch conduits are taken from the junction box on the switch rack, down and under the floor, and up to the motor controller which is usually at or on the machine. The switches used are the commercial type sheet steel safety enclosed switches, which lend themselves admirably to erection in a rack as described.

Use of Network Circuit Breakers

Some thought has been given to eliminating the transformer secondary switches and replacing them with automatic network circuit breakers with automatic overload protection, a desirable feature being that in a plant with a large number of transformers installed it would be possible, with the grid distribution system, to cut out a large number of the stations over Sundays or holidays and in this way save the copper and iron loss involved. This would also allow a few remaining transformer stations to carry the lessened load prevailing. By equipping the network breakers with the proper reverse current relays, it would only be necessary for the switchboard operator to de-energize the primary circuits and the network breakers would automatically disconnect the transformer secondaries from the distribution system. This matter as to whether or not the savings expected will pay for the increased cost of the network breakers must be solved by the plant engineer.

Figure 3 shows a multi-story industrial building arranged with a distribution system very similar to that described, except that one transformer station is usually employed for the building, and risers are run from the transformer station up through the various floors. Bus feeds are taken from the risers through fused switches to feed the bus in the center of the building. It should be noted that one bus feeds two floors. Column feeds are run down for one floor and up for the other.

Switch racks are installed at suitable columns feeding from the bus, and branch circuits are taken from the branch switches and run under the floor into small junction boxes; from here they are carried through the floor to the motor controller. The under floor boxes are usually considered a part of the permanent wiring and are not disturbed when a new layout of the floor is being made; as the feeds from these boxes to the motors are the only changes necessary. This gives a very flexible arrangement as a machine may be relocated with little trouble or expense. The overhead lighting by the use of local switches or panelboards can also be fed from the switch rack as previously outlined.

No switch or wire sizes have been given but it may be of interest to know that 4/0 wire was used throughout the scheme shown in Fig. 1 for both a.c. and d.c. buses, and 200-amp., three-pole switches for a.c. and 200-amp., two-pole switches for d.c. on all column feeds. As stated before, however, this is a matter of load conditions which will govern the material used. The use of conduit throughout is also advised. All new wiring done in the plant of the manufacturer where these systems are installed is wired as described. This includes all wiring from the secondary side of the trans-

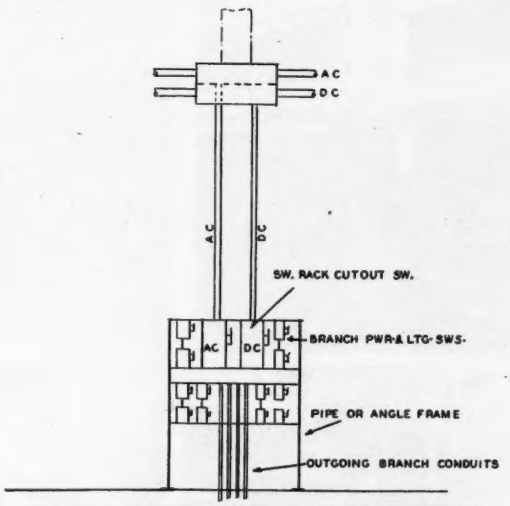


FIG. 13. METHOD OF INSTALLING SWITCHES

former out to the remotest branch point of the system. This type of construction, once installed, is free from maintenance expense and, being concealed, it is free from mechanical injury.

In the photograph at the head of this article is shown the interior of a single-story, two-bay wide industrial building which is used for the manufacture of micarta plate. Only one bus line was run through the building due to the small motor load involved. The bus can be seen running through the center of the building and some of the switches may be visible on the columns. The junction boxes for tapping in circuits are also evident. The three smaller conduits closer to the roof are 1 in. in size and are respectively for telephone, fire alarm, and police circuits. These are run the entire length of the building. The heavier power conduits are seen just below. The top one is 2½ in. and contains 4—4/0; the next, 2 in. and contains 2—4/0. The other conduit is 1½ in. and carries some special circuits not always en-

countered; in this instance, a whistle blowing circuit for electrically operated starting and stopping whistles, and an emergency lighting circuit. It will also be noted that all wiring is in conduit and that the RLM dome reflectors are suspended with ½-in. flexible metallic conduit. Two 30-A safety switches are installed on each side of the building, giving three lights per switch. The lamps are 500-w. and give an illumination of 15 foot-candles on the working plane.

Figure 4 shows an example of a wiring installation for a 2300-v. synchronous motor driving a hydraulic pump. The 2300-v., 3-phase, L.C. cables are run underground from the distributing switchboard into the motor starters. The sheet steel boxes on the side of the foundations contain automatic relay equipment which control the magnetic clutches on the motors driving the

FIG. 14. A VAPOR PROOF WIRING AND LIGHTING JOB FOR A PAINT AND VARNISH DEPARTMENT

pumps. These clutches are actuated by limit switches in the accumulator tanks into which the pumps feed.

Figure 5 shows old open type construction being replaced by that shown in Fig. 6.

Figure 7 shows a typical transformer station setup just before completion with the transformers installed in a vault. The 4-wire secondary bus can be seen above the transformer and the incoming power cables at the lower left. In this particular case, the secondary leads from the transformer are carried out of the vault underground to a secondary distribution board where they are fused.

In Fig. 8 is shown the interior of a rolling mill building and the buses may be seen in conduit along both sides of the building. A large switch rack for distribution is situated at the left end. The equipment installed on the balcony is the automatic control and starting contactors for some of the mill motors. The master controllers are located in the central pulpit of the mill.

An illustration of a control switch rack for a battery of electrically heated wire enameling machines is shown in Fig. 9. On this rack, disconnecting switches are mounted for the heaters and driving motors together with pyrometer controlled contactors for automatic heat regulation. The separate group of switches, motor line-starters and push buttons at the right is for the ventilating fans. In Fig. 10 a similar installation with the pyrometers mounted directly on the rack is shown.

Figure 11 is a view of a transformer station for supplying lighting alone. The total absence of open wires is to be noted; also, the manner in which the safety switches are racked.

Another typical conduit bus installation is shown in Fig. 10. Buses are installed on both sides of the aisle to service the floor properly, since there are a large number of big motors in this aisle. The buses are installed in conduit and may be seen running lengthwise of the room at the side of the crane rail girders.

This article has been written, with the accompanying cuts, in the belief that it may furnish some helpful information relative to proper wiring. Various digressions and changes may suggest themselves to other plant engineers but, in general, it is believed that the schemes as outlined will prove satisfactory. It is to be remembered that a good wiring job always pays in the long run.

Distant Control of Water Level

SCHEME FOR DISTANT CONTROL OF WATER LEVEL USING STANDARD EQUIPMENT. BY C. O. VON DANNENBERG

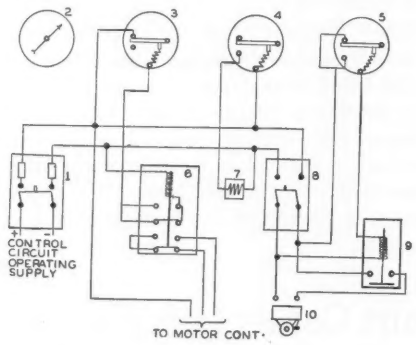
IN THE OPERATION of a service water system in a power station, the necessity for providing accurate and positive control is obvious. As a general practice, the water is delivered by a motor driven pump to a tank located either on the roof of the station or on a steel structure away from the building. In either case, the elevation of the tank is determined by the particular requirements of the installation.

Due to the fact that it is desirable to maintain the level in the tank within fairly close limits and due also to the fact that the ratio of the variation in total pressure in the total system is comparatively small, through the normal operating range of levels in the tank, it is not unusual to find that the automatic control is dependent on an ordinary float switch or similar equipment mounted at the top of the tank. While this method of control is simple and gives satisfactory service with proper maintenance, its inaccessibility, particularly during a case of trouble occurring in winter or bad weather, suggests the desirability of modifying the control system so as to allow routine periodic inspection to be made with the same ease as with the other equipment in the station. It is certainly true that the dangers involved in making an operator climb to the top of an elevated tank under all weather conditions make it desirable from a safety standpoint as well as an operating feature to eliminate such conditions.

USE OF CONTACT MAKING GAGES

The method of automatic pressure control through the use of contact making gages of the Bourdon type is well known and has been in use for many years. The gages may be located, together with the necessary auxiliary equipment, at any convenient point in the station although some place closely adjacent to the pumping

equipment is usually preferable. It is desirable, if possible, for best results, to have the gages receive pressure directly from the tank by means of a pressure pipe, which should not be less than ¾ in. and can be carried along with the discharge pipe from the pump. In cases where this is impossible, very satisfactory results can be obtained by connecting the gages directly to the discharge line, inserting between the gage and the top point a compression tank which will enable any fluctuations in the discharge line to be "cushioned" and prevent the gages from jumping during the starting period and giving some erratic action until conditions are steady. The gage vendor usually recommends the size of the "cushioning" feature although experience indicates that larger tanks are sometimes desirable.



1-SWITCH FOR CONTROL ENERGY SUPPLY
2-ALTITUDE GAUGE WITH SUPPRESSED SCALE
3-STARTING CONTACT GAUGE
4-STOPPING CONTACT GAUGE
5-ALARM CONTACT GAUGE
6-MOTOR CONTROL CIRCUIT CONTACTOR
7-SHUNT RELEASE RESISTANCE FOR 6
8-ALARM CIRCUIT SWITCH
9-ALARM BELL CONTACTOR
10 ALARM BELL

DIAGRAM OF CONNECTIONS OF WATER LEVEL CONTROL

Where the differences in pressure are considerable one gage with two sets of contacts may be used but in many cases the actual pressure difference is so small that the space between the stationary and movable contacts is limited and any pulsation in the system will cause premature operation of the control equipment. A specific installation to be taken care of required the pumping equipment to start and stop respectively at pressures of 39 and 47 lb.

Reference to a standard contact making gage will indicate the small actual movement of mechanism. To solve this difficulty, two gages were used, one for making contact at the lower pressure only and the other for making contact only at the higher pressure. This arrangement allowed settings to be made which were positive in action and in one installation, after the initial adjustments were made, no further attention, other than periodic inspection, has been required for over 3 yr.

Equipment Permits Easy Inspection

The equipment is simple and is located in the basement of the station where it can be readily inspected when desired.

The appended sketch indicates the general electrical connections of a control system of the type described. The general details are self-explanatory. In addition to starting and stopping, there is another gage which controls an alarm system to indicate whether the level is above or below the prescribed limits. An altitude gage of standard type, with a suppressed scale to give it a broader range for the level limits, is included to indicate to the operator the condition of the tank level particularly in the case of a failure of the control equipment. Three installations of this type have been in operation for periods ranging from 3 to 5 yr.

Operating Code Manual for Power Plants

Satisfactory Operation of Main Equipment Depends Upon Auxiliaries. Directions for Operating Auxiliary Turbines, Engines and Motors Are Outlined Here

MODERN POWER PLANTS have many auxiliaries driven by various prime movers such as turbines, engines and motors, the selection of which depends upon local conditions. Proper operation, however, demands that this equipment be kept in good condition and operated safely.

Small turbines form a common auxiliary drive and the following starting directions are recommended:

Starting Small Turbines on Auxiliaries

1. Inspect the reduction gear to see that no water has accumulated in the case and that there is enough, but not too much, oil.
2. See that the exhaust valve is open.
3. See that the relief valve on the turbine casing is in operating condition.
4. Inspect the oiling system and the oil strainer, if it is accessible.
5. See that all drains are open.
6. If an emergency trip is provided, see that it is set.
7. See that the overload nozzle valves are closed.
8. If condensate has accumulated in the auxiliary steam line, drain it off.
9. Open the throttle slightly and run the unit at a low speed.
10. Sound the turbine.
11. Inspect the oiling system before and after starting to see whether it is functioning properly.
12. Open and adjust the proper supply of water to the oil cooler and bearing water jacket, if any.
13. Bring the turbine up to speed gradually.
14. Close all drains when the turbine is up to speed.
15. If turbine glands are of the water-sealed or steam-sealed type, see that they are properly sealed.
16. Test the governor by pushing it to the closed position to see whether this will cause the turbine to slow down.

17. Overload nozzles are to be used only when necessary.

Shutting Down Small Turbines on Auxiliaries

1. See that load is off the turbine whenever practicable.
2. Close the throttle valve.
3. Do not shut off the oiling system until the unit comes to rest.
4. Close the exhaust valve every time the machine is shut down.
5. Open the drains.

Small Turbines Periodic Overspeed Test

1. See that the load on the turbine has been removed, when practicable.
2. Apply a tachometer to the shaft and note that normal speed is maintained by the governor at no load.
3. Continue to observe the speed by means of the tachometer and force the governor arm against the spring, allowing the turbine to speed up, not exceeding 2 per cent above the speed at which the manufacturer recommends setting the emergency trip.
4. Note the speed at which the overspeed device trips the throttle and, if this speed is more than 2 per cent above the speed at which the manufacturer recommends setting the emergency trip, locate cause and make any necessary adjustments to governor mechanism and safety devices.
5. Be sure the tripping mechanism is correctly adjusted before putting the machine into service.

Starting Slide Valve Engines on Auxiliaries

1. Open the exhaust valve.
2. Open necessary valves on auxiliaries connected to the engine.
3. See that the drains and cylinder cocks are open.
4. See that the lubricator is acting properly and inspect the oiling system before and after starting.
5. Open the throttle valve enough to admit steam to warm up the cylinder without turning the engine.
6. Bring the engine up to speed gradually and inspect the operation of the governor and safety devices.
7. Close the drains.

Shutting Down Slide Valve Engines on Auxiliaries

1. Close the throttle and stop the engine in the starting position.
2. Shut off the oiling system when the unit comes to rest.
3. Close all valves on auxiliaries connected to engine.
4. Close the valves on the lubricator.
5. Open the drains before closing the exhaust valve, if noncondensing.
6. Exhaust valve should be closed and drains open.

Starting Small Motors on Auxiliaries, Synchronous Motors

1. If possible, see that the load is off the motor.
2. Inspect the oiling system.
3. If possible, throw field switch to short-circuit the field windings; otherwise, see that field switch is open.
4. Close the starting switch and note that the rotor turns over.
5. After the motor comes up to maximum speed on the starting switch, open the starting switch and immediately close the running switch.
6. After the motor comes up to maximum speed on the running switch, see that all the field resistance is cut in, close the field switch and adjust the field for the minimum or the prescribed leading armature current.
7. Inspect the oiling system and note whether it functions properly.

Shutting Down Synchronous Motors

1. See that all load is off motor, if possible.
2. Open the running switch.
3. Cut all field resistance in.
4. Open the field switch.

Starting Induction Motors by Compensator

1. Inspect the oiling system.
2. See that the compensator handle is in the "Off" position.
3. Close the motor main switch.
4. Throw the compensator handle to the starting position and note that the rotor turns over, or watch ammeter if it is impossible to see motor.
5. When the motor comes up to maximum speed on the starting position, throw the compensator handle to the running position quickly.
6. Inspect the oiling system and note whether it is functioning properly.

Shutting Down Induction Motors by Compensator

1. Trip the compensator.
2. Open the motor main switch when compensator handle is in "Off" position and motor has begun to slow down.

Starting Motors Started from Automatic Control Panel

1. Inspect the oiling system.
2. See that the controller is in the "Off" position.
3. Close the motor main switch.
4. Move the controller handle to the required starting position.
5. Note that the starting operations are in proper sequence and that the motor comes up to the required speed.
6. Inspect the oiling system and note that it is functioning properly.
7. Inspect the slip rings if the motor is of the slip ring type.

Shutting Down Motors from Automatic Control Panel

1. Move the controller handle to the "Stop" position.
2. Open the motor main switch, wherever practicable. (Note: If motor main switch is knife type, open switch when rotor has stopped turning.)

Electrical energy is converted into heat whenever an electrical current flows through a conductor. This loss is known as the $I^2 R$ loss and is equal to the product of the resistance in ohms and the square of the current in amperes.

Further Comments on Industrial Refrigeration

PRODUCTION OF LOW TEMPERATURES IN TEXTILE, PAPER, WIRE, AND FOOD INDUSTRIES, AS WELL AS MANY OTHERS

PREVIOUS ARTICLES on this subject have called attention to unusual applications of refrigeration in various industrial processes and the present article will discuss other applications of the same type. Such information should be of interest to the industrial power plant engineer because it has been shown that many processes can be carried on with the aid of refrigeration that would otherwise be difficult or even impossible. Engineers may therefore be helped in solving their own problems by some data on what other industries are doing.

The textile industry has increased its use of refrigeration materially in the past few years, particularly in rayon mills, where water is cooled and air conditioned for process work. In a certain plant making mercerized fabrics, the caustic soda used in baths for bleached goods is cooled by recirculating the liquid over cooling coils that reduce its temperature from 95 deg. F. to about 60 deg.

Figure 1 shows two of the six duplex Frick ammonia compressors supplied to a large rayon company for one of its plants. These are two-stage units, 12¼ by 20 by 21 in., with clearance pockets on both cylinders. Each machine produces 180 t. of refrigeration at 180 r.p.m. and each is driven by a 500-hp. motor mounted directly on the shaft. The plant chills brine to a low temperature in a battery of huge multipass coolers. Accessories include shell condensers, liquid forecoolers and flow meters for both brine and ammonia.

Many interesting uses of refrigeration are made nowadays in metal working. For example, in some special experiments on metal stresses, test pieces of metal are chilled to 60 deg. F. before being subjected to experiment by immersing them in CO_2 snow; ammonia coils prevent excessive melting of the snow.

In the preparation of cod liver oil, stearic acid is frozen from the oil by cooling it to 35 deg. F. over cooling coils.

In a cable factory, the cable wire is heated in an oven to anneal and dry it. The oven, with the wire inside, is then cooled by direct expansion coils.

Loading cellulose on paper or leather to give a crackle finish with spider-web design; cooling chemicals from tank cars before discharging them to storage tanks; holding valuable germ cultures automatically at temperatures between 34 and 35.5 deg. F.—these are typical of some uses of cooling systems.

Some of the most interesting applications are, of course, in the preparation and storage of food products. Figure 2 shows a refrigerated room for sausages.

Whether chewing gum can be called a food product or not, its manufacture is aided materially by use of humidity and temperature control equipment including unit coolers and heaters. In one room of such an industry the temperature is kept at 75 deg. with 60 per cent humidity while in another it is at 50 deg., 60 per cent humidity.

In growing mushrooms, cooling coils above the beds have been used to keep the air at 55 deg. F., to control the growth of the mushrooms.

One of the most unusual cooling applications in the food industry is in connection with a watercress farm. After the cress is cut, it is put in open crates, carried to the packing house and lowered into the precooling tank where streams of cold water reduce the temperature of the cress from 72 to 34. Each crate remains in the water 10 to 15 min. The cress is then packed in boxes that have been previously chilled in the cold storage room. As this room is held at 31 deg. F., the packed boxes are kept in it without fear of melting the ice until shipment is made. This method makes it possible to ship the watercress by express to leading hotels and dealers all over the country so that it will reach them, packed in

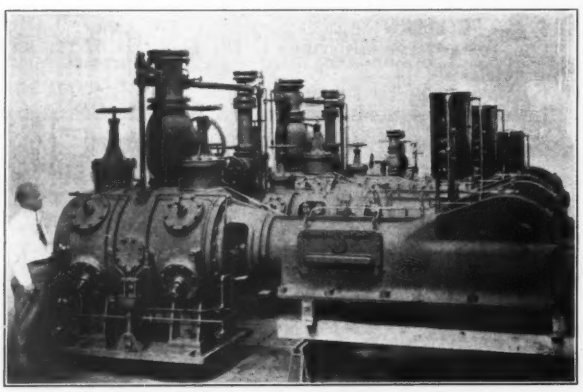


FIG. 1. TWO 180-T. AMMONIA COMPRESSORS FOR A RAYON MILL

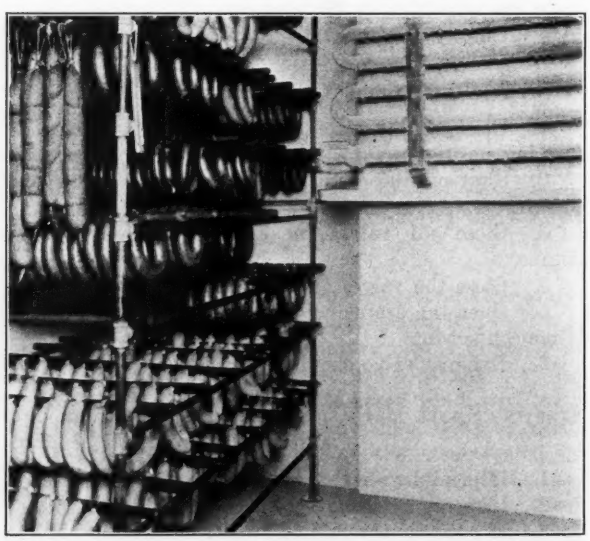


FIG. 2. REFRIGERATED ROOM FOR STORING SAUSAGE

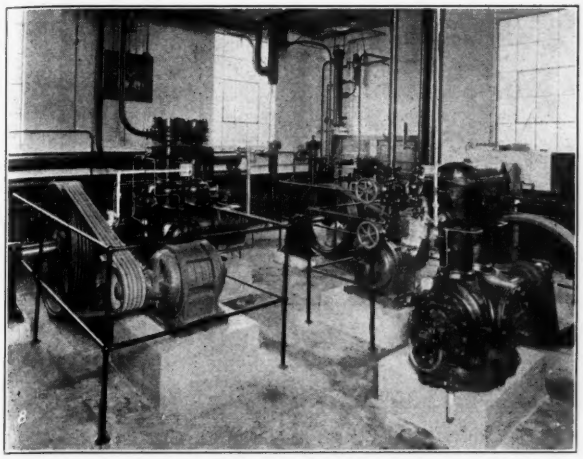


FIG. 3. THREE-STAGE COMPRESSORS USED IN MAKING CO_2 SNOW

ice, in first-class condition. This farm ships about 5,000,000 bunches of cress a year.

Such methods as these have made it possible to grow and ship food products in ways that could not be attempted before. The possibility of being able to chill the product quickly to prevent initial spoilage and the provisions for keeping it at low temperature during transit have had an important effect on the food industry.

Great interest has also been displayed in the use of silica gel and CO_2 snow for such purposes. Figure 3 shows three Frick CO_2 compressors for three-stage compression used in the manufacture of CO_2 snow at a large eastern plant. By a system of intercoolers and heat exchangers, the liquid CO_2 is flashed into snow at —109 deg. F. with little loss of refrigeration or power.

Hydrogen for Cooling Large Equipment

HYDROGEN COOLING, by which it becomes possible to reduce electric losses to about 75 per cent of the value obtained with air-cooled equipment, is to be used with a 50,000-kv-a. synchronous condenser which is being constructed at the Schenectady works of the General Electric Co. for outdoor installation at the La Fresa substation of the Southern California Edison Co. Totally-enclosed, hydrogen-cooled synchronous condensers have been built previously by the General Electric Co. but none has approached the new unit in size or capacity. It is rated 50,000 kv-a., 13,200 v., 600 r.p.m., three phase, and 50 cycles. The excitation will be furnished by a separate motor-generator set with a pilot exciter.

The advantages of hydrogen cooling, introduced by the General Electric Co., are numerous. Not only can losses in a machine be decidedly decreased but, if desired, the capacity can be increased for a given size of machine. Oxygen and dirt are excluded by the air-tight casing. Hydrogen will not support combustion and fires of any kind—even from short circuits—are consequently impossible. Hydrogen also greatly reduces the effect of corona on the insulation. The totally-enclosed, hydrogen-cooled machine is exceptionally quiet in operation, so may be installed in residential districts where noise would be objectionable.

In the case of air-cooled equipment there is considerable loss in operating efficiency because of the resistance of the air against the rotating element. Hydrogen is much lighter than air, and the wind resistance loss is reduced to about 10 per cent of the loss in air if the hydrogen is used at atmospheric pressure.

The condenser is enclosed in a gas-tight, explosion-proof cylinder, provided with end bells. An extension on one end of the casing encloses the slip-ring mechanism. A seal is placed around the shaft where it enters the housing, so that the brushes may be adjusted or replaced without losing hydrogen from the main shell. The bearings are supported by structural steel frameworks welded to the inside of the casing.

Hydrogen, a good heat conductor, removes the heat much more rapidly than would air. The heat absorbed by the hydrogen is removed by four internal surface-type coolers, consisting of nests of pipes arranged concentrically inside the shell and close to each end of the casing. Hydrogen is drawn in along the field structure by fans placed at the ends of the shaft and is forced radially outward through ducts in the armature laminations. It then passes back along the inside of the shell to the coolers, after which it is again drawn into the machine by the fans and recirculated. The cooler pipes are supplied with circulating water.

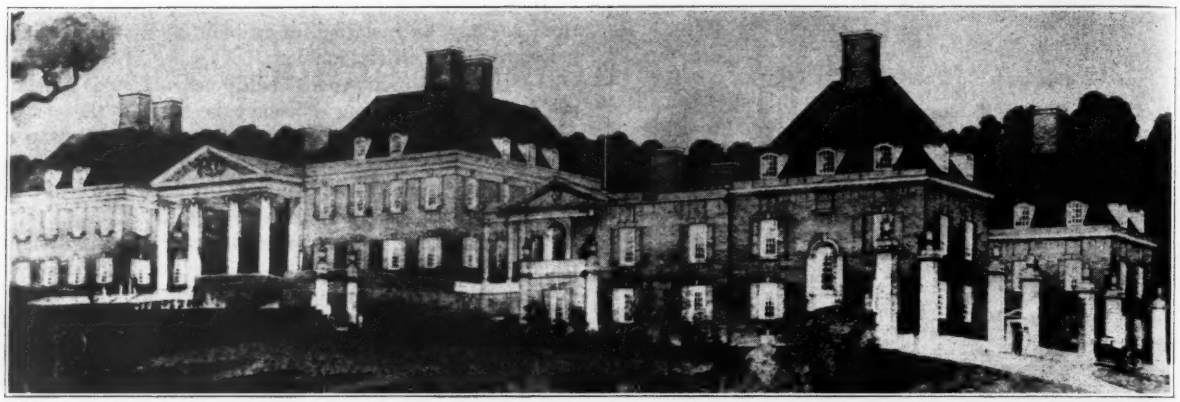
A pressure-regulating switch and valve maintain the hydrogen pressure sufficiently above atmospheric pressure so that leakage, if any, will be outward, thus preventing the contamination of the gas by air. A recorder in a cabinet attached to the casing gives a continuous indication of the purity of the gas and operates an alarm if the purity falls below 91 per cent.

The condenser is kept so tight that the loss of the gas is negligible. Any loss is made up by hydrogen that is automatically drawn from a commercial cylinder of the gas connected to the piping system. Since a hydrogen and air mixture containing more than 70 per cent of hydrogen by volume is noninflammable, there is an ample factor of safety against ignition of the cooling medium. As an added precaution, however, the casing is strong enough to withstand the disruptive force of the most explosive mixture of hydrogen and air.

Oil-pressure starting, and indicating thermometers on the bearings are other features of the equipment. The thermometers operate an alarm if the temperature exceeds 140 deg. F. Another thermometer, indicating the temperature of the hydrogen as it leaves the cooler, rings an alarm if that temperature exceeds 104 deg. F.

Hydrogen cooling of synchronous condensers has occupied the attention of electrical engineers for a number of years. The General Electric Co. has done extensive research work in this field, and previous installations of smaller hydrogen-cooled condensers have been in successful operation during the past two years.

COSTS OF steam accumulators depend primarily upon the load. If fluctuations are of short duration, small accumulator capacity is sufficient but if of long duration, more capacity is required and the cost will increase.



Panel Heating at the British Embassy

NEW BUILDING IN WASHINGTON, D. C., INCORPORATES FIRST INSTALLATION IN THIS COUNTRY OF SYSTEM DEVELOPED SEVERAL YEARS AGO IN ENGLAND AND USED SUCCESSFULLY THERE. BY ALFRED L. JAROS* AND RICHARD A. WOLFF†

ATTENTION was called in the May 15, 1930, issue of Power Plant Engineering to a development in heating systems known as panel heating that seems to be little known in this country, although it was developed several years ago in England and has been in successful use there under varied conditions. As a matter of fact, the first installation of panel heating in this country is at the newly completed British Embassy at Washington. Below are given some of the important details of the system as installed there.

As noted in the previous article on panel heating, the system is one in which heat distributed from a central boiler plant is radiated into the individual rooms, usually from the ceiling, by means of wall surfaces of plaster or other suitable material.

The radiating surfaces are commonly in the ceiling and are kept at very mild heat. Rarely, if ever, will the surface of the plaster be hotter than 120 deg.

In order that a large area of plaster or other building material shall act as a radiator of heat, it is necessary to introduce heat into the material itself. This is accomplished by coils of steel pipe buried in the building construction immediately behind the bulding surface which is to radiate the heat. Through these coils, water is circulated at a temperature varying according to the weather. Heat from the water is conducted through the metal of the pipe and through the plaster to the surface which is to be kept warm.

In the accompanying illustrations are shown the new British Embassy building and some of the details of the panel heating system installed there and operating on the principles briefly noted above. The structure contains 700,000 cu. ft. consisting of two main buildings joined by a connecting space over a large driveway. The northerly wing, the right-hand one in the headpiece, is the chancery and office building for carrying on the business of the Embassy; the southerly wing is primarily the home for the ambassador, his family, guests and servants. The buildings are all fireproof construction throughout.

In general, the walls are of brick and the most typical floor construction consists of a bottom arch of concrete carried by structural steel beams—an air space above the concrete between the beams, a slab of nailcrete reinforced with hy-rib at the top of the beams and a wood floor laid on the nailcrete. There are various modifications—marble floors are used largely in certain portions of the building as are also hung ceilings in other portions. The mechanical and electrical equipment throughout is of the most modern and complete character and it was in line with this that the decision was made to follow the practice that has obtained in many of the most notable recent buildings by installing the panel heating system.

For motives of economy in first cost, the Chancery building and garage are heated with exposed steam radiators. The Embassy building, however, except for a few unimportant attic rooms, is entirely heated by panel heating.

*Of Jaros & Baum, Consulting Engineers, New York City.
†Of Wolff & Munier, Inc., Heating Engineers and Contractors, New York City.

FIG. 1. METHOD OF PLACING HEATING PANELS IN CEILING

The boiler plant contains two large steel boilers fired with fuel oil. Steam from these is piped through an underground tile conduit to the Chancery building and to the garage. Steam from the same boilers is supplied to converters of the cast-iron shell and water-tube type, thermostatically controlled to maintain the water temperature continuously at any desired point, according to weather requirements.

Motor-driven centrifugal circulating pumps in duplicate circulate the heated water to and from all the panel coils in the Embassy. Domestic hot-water tanks of the steel coil type supply the hot-water requirements.

Returns from all these converters and heaters and from the smaller steam heated building are handled by vacuum return pumps which deliver the returns to the boilers.

The central plant has a total capacity of 175 boiler hp. or an equivalent capacity of about 22,000 sq. ft. of standard radiation. The actual load carried in the most severe weather with the building fully occupied and used will be about 125-hp. Each of the boilers is large enough so that the two are needed only in severe weather.

All coils and concealed piping are of extra heavy steel pipe put together entirely by welding. Electric welding for the factory made coils and autogeneous for the field connections. In general, the piping system is arranged with overhead supply mains, down feed supply and return risers and return mains run in the basement and in trenches and underground spaces. All risers are concealed in chases and furred spaces in the walls. Radiator branches, whose vertical portions are run in the same spaces with the risers, run horizontally either in the floor slab, in the ceiling or other similar spaces to suit the individual conditions.

To avoid difficulties of adjustment, a special effort

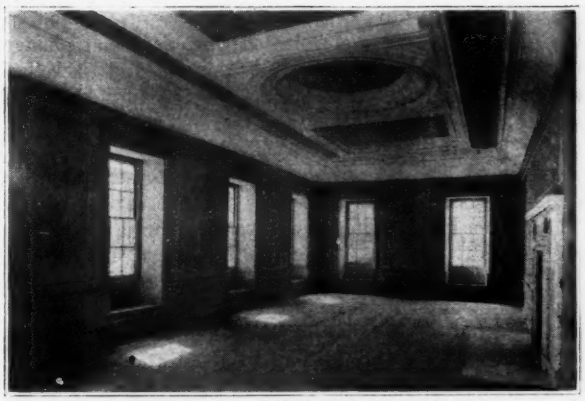


FIG. 2. ONE OF THE PANEL-HEATED ROOMS OF THE BRITISH EMBASSY. ALL THE COILS ARE IN THE CEILING AS SHOWN IN FIG. 3 AND NO HEATING EQUIPMENT OF ANY KIND IS VISIBLE IN THE ROOM

was made to design the piping system so as to secure automatically a balanced condition of floor in respect to all the various scattered coils, a total of 204.

The results have been thoroughly successful,—no adjustment or throttling of the system has been found necessary and after the system has been properly filled a thorough and perfectly balanced circulation is secured through all portions of it.

About 75 per cent of the coils are cast in the bottom of the concrete slabs, about 10 per cent are cast in the floors or in side wall panels to meet special conditions at doorways, entrance corridors and rooms whose floors rest upon the earth or upon unheated spaces. The remainder, about 15 per cent, of the coils are located in hung ceilings which, except for the coils, are similar in construction in every way to other hung ceilings. In

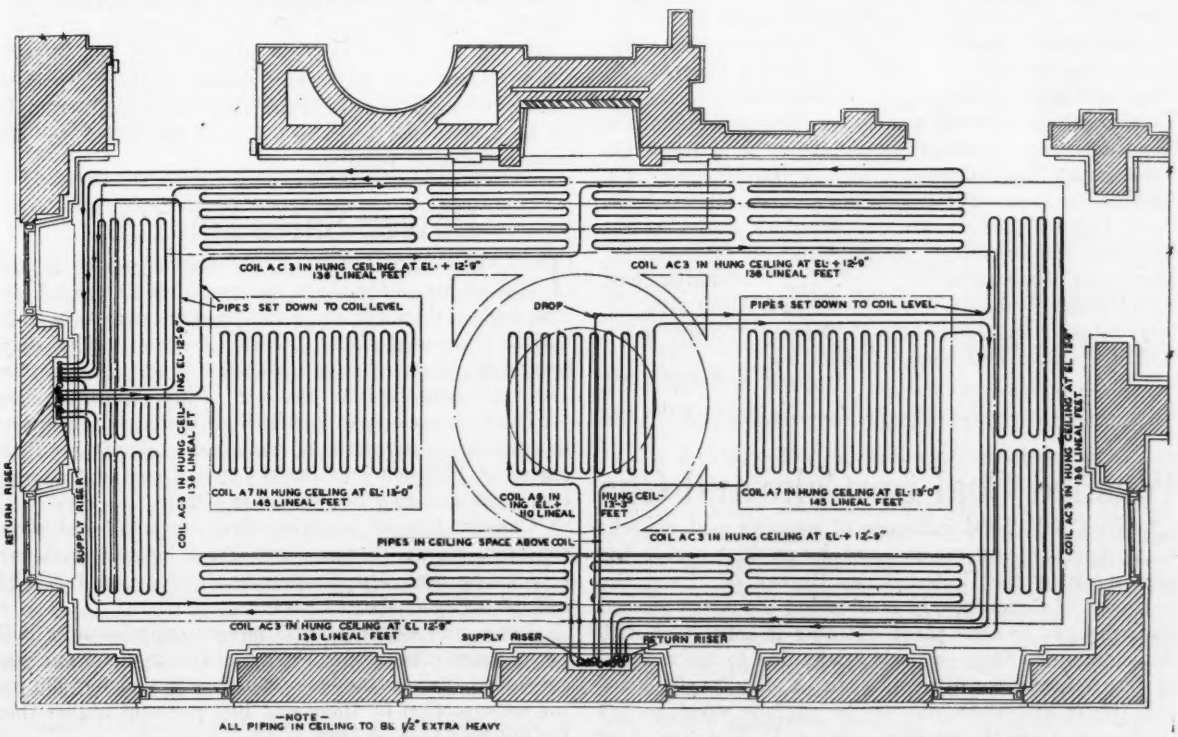

COIL AC 3 IN HUNG CEILING AT EL. + 12'-9" 136 LINEAL FEET
COIL AC 3 IN HUNG CEILING AT EL. + 12'-9" 136 LINEAL FEET
PIPES SET DOWN TO COIL LEVEL
PIPES SET DOWN TO COIL LEVEL
DROP
COIL A7 IN HUNG CEILING AT EL. 13'-0" 145 LINEAL FEET
COIL A7 IN HUNG CEILING AT EL. 13'-0" 145 LINEAL FEET
COIL AC 3 IN HUNG CEILING AT EL. + 12'-9" 136 LINEAL FEET
PIPES IN CEILING SPACE ABOVE COIL
COIL AC 3 IN HUNG CEILING AT EL. + 12'-9"
COIL AC 3 IN HUNG CEILING AT EL. 12'-9" 136 LINEAL FEET
SUPPLY RISER
RETURN RISER
RETURN RISER
SUPPLY RISER
—NOTE—
ALL PIPING IN CEILING TO BE 1/2" EXTRA HEAVY

FIG. 3. SHOWING HOW THE COILS ARE INSTALLED IN THE CEILING OF THE ROOM SHOWN IN FIG. 2

plastering the ceilings, a rough plaster was erected in the usual way; for the white coating, a special plaster used for this work was carefully applied and trowelled on and scrim reinforcement was at once applied to the wet surface of the plaster and worked up into it with the trowel until completely embedded.

On a 40-deg. day with an average water temperature of 115 deg. in the coils, tests were made of various rooms. The consensus of opinion of several observers was that substantially comfortable conditions were experienced in the room maintained at or slightly below 60 deg. and that complete comfort was experienced at about 62 deg. A sensation of serious overheating was experienced when the temperature was maintained at 66 deg.

Actual installation cost of the British Embassy panel heating installation is figured to be about 12½ per cent more than that for the usual type of steam plant.

The British Embassy was designed by Sir Edwin Lutyens, R. A., associated with whom as supervising architect was Frederick H. Brooke, of Washington, D. C. The heating design was originated by Messrs. Richard Crittall & Co., Ltd., of London; while the actual plans and specifications were drawn by Messrs. Jaros & Baum (Consulting Engineers) of New York City, to conform with American weather conditions, materials and structural methods. The plans as finally issued represent the collaboration and joint ideas of both firms.

Wardman Construction Co., of Washington, D. C., were the builders and general contractors for the Embassy. The heating plant was installed by Wolff & Munier, Inc., of New York City, (under American license from Richard Crittall & Co., Ltd.) The oil-burning equipment was installed by the Winslow Kleen-Heat Corp.

Principal equipment and materials used in the heating installation were as follows:

Boilers.....Heggie-Simplex Boiler Co.
Heating-system heaters.....The Patterson-Kelley Co.
Circulating pumps.....Goulds Pumps, Inc.
Vacuum heating pumps.....Nash Engineering Co.
Thermostatic control of heaters....Fulton Sylphon Co.
Nonconducting covering.....Keasbey & Mattison Co.
Sheet metal fabrication.....J. D. Thompson Co.
Underground conduit.....Ric-Wil Co.
Panel heating coils.....Whitlock Coil Pipe Co.
Cast-iron radiators.....American Radiator Co.
Hand and check valves.....Jenkins Bros.
Boiler water feeders.....McAlear Mfg. Co.
Heavy-duty traps (on heaters)..Warren Webster & Co.
Radiator valves and traps (Chancery).....
.....Warren Webster & Co.
Pipe.....National Tube Co.

Washed Coal for Coke and Gas

STUDY OF THE influence of washing coal on coke properties and on gas and by-product yields has been made by the United States Bureau of Mines, Department of Commerce. In considering the use of washed coal, the gas or coke plant operator is concerned with two classes of effects—namely, those due to the removal of free mineral constituents such as slate, shale, bone, and pyrite and those due to the surface moisture left in the coal from the washery, says A. C. Fieldner, chief engineer of the Bureau's experiment stations division, in summarizing the results of the study. All of the first class are desirable, as they improve the quality of the carbonization products. The second class of effects, those due to moisture, are complex, partly desirable, but mostly undesirable, especially with a material increase of moisture in the coal.

The favorable effects of eliminating free mineral impurities may be summarized as follows:

1. Improvement of coke quality.
   a. Reduction of ash and sulphur.
   b. Less clinker trouble.
   c. Fewer cross fractures in coke, resulting in greater resistance to breakage on handling, less small coke and breeze.
   d. Greater uniformity in chemical composition and physical properties of coke.
2. Less sulphur in gas.
3. Greater yield of gas and by-products per ton of dry coal charged.

The adverse effects of moisture are:

1. Reduction of oven capacity and throughout, due to lower charging density of moist coal, and longer time required to complete coking at a given temperature.
2. Higher fuel consumption per ton of coal carbonized.
3. Nonuniform coke, due to wet spots in charge.
4. Excessive moisture, 12 to 15 per cent, causes large-celled, weak coke.
5. Dripping wet coal may cause spalling of the brick oven lining.

On the credit side of the ledger, moisture increases the ammonia yield, and reduces carbon deposits on the oven walls. Its effect on gas, light oil, and tar is open to question. Other variables, such as temperature, coking time, and amount of moisture complicate the situation, and in the absence of further data, no definite conclusions can be made with respect to these products. On the whole, it seems certain that the moisture should be kept low (not to exceed 4 to 5 per cent) for the most economical results.

Power Sales for 1930

TOTAL CONSUMPTION of electric power in the United States for the first 6 mo. of 1930 was 1.7 per cent higher than for the corresponding period in 1929 and 15.1 per cent above that for the first half of 1928, according to the National Electric Light Association. The total consumption was 37.8 billion kilowatt-hours.

Use of electricity by domestic or household customers is considered particularly significant, showing an increase of 13.7 per cent for the first 6 mo. of this year over 1929 and 29.8 per cent over 1928.

Consumption of electric power by small industrial concerns, stores, theaters, for street lighting and corresponding uses, was 6.8 per cent above that for 1929, and 24 per cent above 1928.

Large industrial plants, mines, quarries and bulk power users consumed 2.2 per cent less in the 6 mo. just concluded than in the corresponding period in 1929 but the consumption by them was 10.3 per cent higher than for the first half of 1928.

Economics of Hydroelectric Projects

COMPARISONS OF SEVERAL ALTERNATIVE SCHEMES FOR THE DEVELOPMENT OF A SMALL RIVER, AT VARIOUS LOAD FACTORS AND WITH VARIOUS FLOWS. BY BYRON E. WHITE*

THIS PAPER deals with the economics of water power development, particularly as related to hydroelectric projects. Past and present practice in the development of water power are discussed, as well as the economic factors which have brought about the recent changes in hydroelectric practice, including specialization in industry, increases in the efficiency and capacity of generating equipment, decrease in the space requirement per unit of power, the lowering of the cost of energy, and the linking together of independent power sources into great systems. The relation of improved efficiencies and the decreased cost of fuel generated power to the economics of water power plants is also discussed.

Water power plants are classified on the basis of the available stream flow and the degree of regulation effected by storage reservoirs. Economic justification of water power plants versus fuel burning plants is discussed, as affected by the elements of firm capacity and annual primary energy output. Effects of different load factors and of variations in the cost of the elements of a hydro project, such as the water storage, the dam, the water conduit, the power house, and the equipment, as well as the effect of local physical conditions on these costs, are briefly treated. Desirability of simplification and reductions in the cost, while retaining efficiency and reliability, are discussed, together with a review of many recent developments, tendencies and inventions, whose use under suitable conditions promotes economy. The testing of models of hydraulic structures and machines for economy, performance and reduction of cost in the finished full-size structure or equipment, is also mentioned.

COMPARATIVE ECONOMIC STUDY OF ALTERNATIVE SCHEMES FOR DEVELOPMENT OF A TYPICAL HYDROELECTRIC PROJECT

To illustrate the methods and means of analysis which may be employed in studying the possibilities of the economic coördinated power and storage development of a river, we may take the case of a small stream, falling about 60 ft. per mile, having a flashy but good average stream flow.

In order to reduce the cost, many recent developments and improvements were incorporated in the hypothetical plans. The existence of narrow box canyons at some sites made constant angle overfall arch dams economical, while at others, semi-hydraulic fill dams with tower spillways combined with intakes and arched outlet conduits were found cheapest, where flood flows are not too great. Umbrella type generators of welded construction, simplified connections and switching, concentration of plant controls at the switchboard, automatic, semi-automatic or supervisory control, automatic frequency control and load division between units, and other features will increase the efficiency and reliability or reduce costs.

Before proceeding with construction or even with detailed designs, some of the rather novel proposed structures should be thoroughly investigated by tests of alternative models, in the expectation that worth while improvements and reductions in cost would probably result.

Since the market for the energy output is in a large interconnected system, transformer costs and costs of transmission to the nearest switching station on the interconnecting lines must be added to the costs of energy at the station bus bars, before it can be compared with the cost of energy from alternative sources.

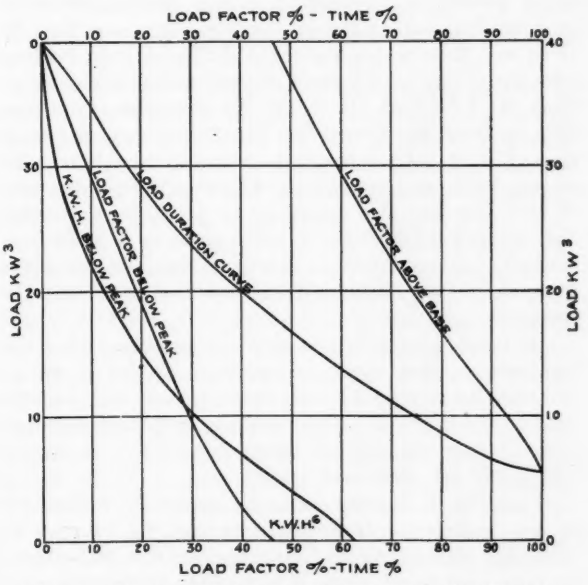


FIG. 1. DURATION AND LOAD FACTOR CURVES OF TYPICAL LOAD

Essential data concerning the projected development are given in Table I.

ALTERNATIVE SCHEMES OF DEVELOPMENT

To illustrate the economics of variations in design and installed capacity, a number of alternative hypothetical layouts were made for the complete development of this stream. These vary from run-of-river plants, through the alternative of partial storage regulation, to that of complete regulation. In addition, the supply of stored water by means of diversion from the main stream by a high hydraulic fill dam and a canal versus pumping were also considered.

Development of each site for high, medium and low load factor operation, relative to the available stream flow, was also considered and the unit energy costs for

*General Engineer, Utica Gas & Electric Co., Utica, N. Y. From a paper presented at the World Power Conference, Berlin, June, 1930.

TABLE I. GENERAL DATA REGARDING HYDROELECTRIC PROJECTS

PLANT NO.	DRAINAGE AREA SQ. MI.	HEAD FT. GROSS	HEAD FT. NET	MIN. FLOW - C.F.S. UNREG.	MIN. FLOW - C.F.S. 2.0 B.C.F. STORAGE	MIN. FLOW - C.F.S. 4.5 B.C.F. STORAGE	K.W.H.* PER S.F.H.	LENGTH OF PIPE LINE - FT.	DAM HEIGHT FT.	DAM TYPE	TRANS. LINE MILES
1	94	415	385	5	175	230	26.2	12400	90	** HYD. FILL	24.75
2	120	125	118	20	185	240	8.05	3500	85	ARCH	22.25
3	128	279	255	25	190	250	17.3	14900	80	ARCH	19.25
4	187	200	180	40	200	260	12.3	9500	90	ARCH	14.5
TOTALS		1019	938								
DIVERSION DAM									65	HYD. FILL	*** 7.0

Drainage areas: Above diversion dam, 75 sq. mi.; above storage dam, tributary area only, 19 sq. mi.; above storage dam, including diversion, 94 sq. mi.; between diversion dam and dam No. 2, 26 sq. mi.

*At 80 per cent overall efficiency.

**Storage reservoir dam.

***From Plant No. 1.

each estimated. These costs are shown in Table II, and on Fig. 4.

The topography of the watershed presents the interesting possibility of creating a large storage reservoir on a small tributary stream, having a drainage area of 19 sq. mi., from which a conduit of 2½ mi. long, leading over the divide to the main stream, will create a maximum gross head of 415 ft. At the same time, it is possible to divert the flow of the upper portion of the main river (75 sq. mi.) through a natural channel into the storage basin or, alternatively, to pump the greater part of this flow into this reservoir, by a pumping installation, located either in No. 1 power house or at a low dam at the site selected for the diversion dam and the water pumped a few hundred feet over the divide to the reservoir.

A third alternative is that of pumping into the reservoir the flow of the stream from the 26 sq. mi. of drainage area lying between the diversion dam and the dam of Plant No. 2. For pumping, surplus or off-peak hydro power, or off-peak steam power, at "increment cost," will be considered.

Plant No. 1, therefore, may be installed for operation at any load factor from that of a high load factor, or base load plant, to that of an extremely low load factor, or peak load plant, since it is possible to create a storage of volume sufficient for practically complete equalization of the annual tributary stream flow, except in unusually wet years. In some years, the natural inflow

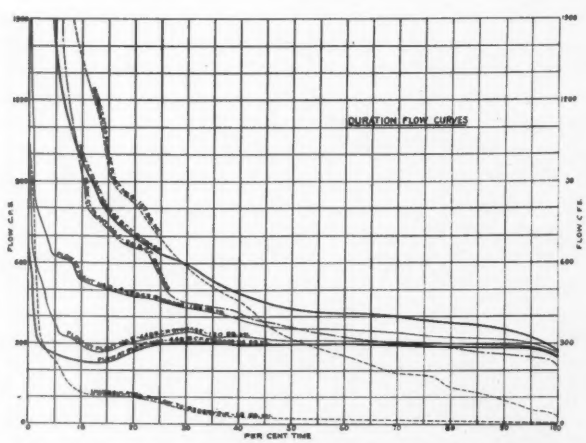


FIG. 2. DURATION CURVES OF STREAM FLOW AT THE DIFFERENT SITES

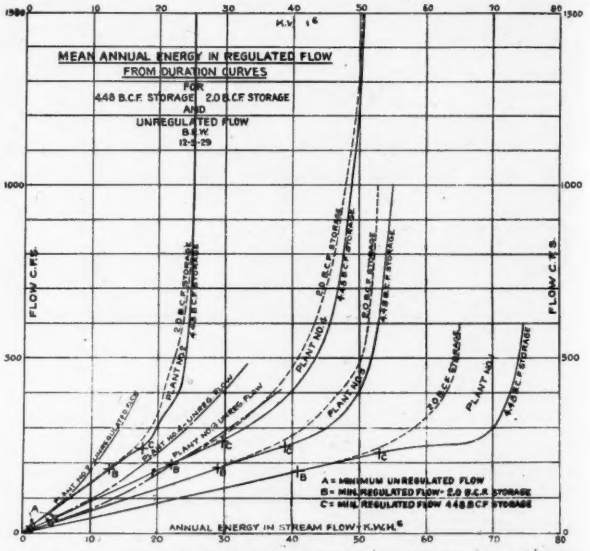

MEAN ANNUAL ENERGY IN REGULATED FLOW
FROM DURATION CURVES
FOR
4.48 B.C.F. STORAGE 2.0 B.C.F. STORAGE
AND
UNREGULATED FLOW
B.A.W.
12-6-29
FLOW C.F.S.
ANNUAL ENERGY IN STREAM FLOW - K.W.H.
A = MINIMUM UNREGULATED FLOW
B = MIN. REGULATED FLOW - 2.0 B.C.F. STORAGE
C = MIN. REGULATED FLOW 4.48 B.C.F. STORAGE

FIG. 3. MEAN ANNUAL ENERGY IN REGULATED FLOW FROM DURATION CURVES

plus the diversion would fill the reservoir to overflowing, with slight waste. In other years, considerable additional water could be pumped into it in order completely to fill it. A 300-c.f.s. pump unit would be sufficient for this purpose.

If the inflow diverted and pumped from the 26 sq. mi. of drainage area between the diversion dam and Plant No. 2 is pumped into the reservoir, an equal range of load factors may be provided for it in the design.

Stream Flow

Figure 2 is a composite duration curve of stream flow at the different sites. For clearness, only the regulated flows with 4.48 b.c.f. storage are shown for all sites, while the unregulated flow and that of 2.0 b.c.f. storage are shown for one site only.

In studying the possibilities of plants of different capacities at the different sites, it was found convenient to construct, first, a set of curves derived by integration of the duration curves, Fig. 2, of regulated stream flow, showing the accumulated stream flow in second-foot-hours (s.f.h.) up to different values of stream flow in cubic feet per second (c.f.s.). Separate curves were made for each of the power sites. Second, a very similar set of energy curves for each site, Fig. 3, was derived from the second-foot-hour curves and the respective project net heads.

To avoid waste of valuable water, and of available head, plants must be so operated that upper plants running at high load factors will possess full ponds at the beginning of such operation, while the ponds of lower plants, into which high load factor plants discharge, must previously be drawn low enough to receive plants are simultaneously operated at higher load factors.

Nearly complete utilization of both regulated and unregulated stream flow may be realized, if the plant capacities are stepped up as the unregulated area increases and a system load capable of absorbing the energy exists.

It is highly improbable that the extreme minimum regulated stream flow and energy output of these sta-

tions will occur at precisely the same time as for the remainder of the water power generating system, as a whole. For this reason, their capacity value to the system may justly be taken at, say, the flow exceeded 95 per cent of the time, instead of the absolute minimum, as given in Tables II and III.

Reserve and Emergency Capacity

If we also take into consideration the possibility of immediately starting up a hydro unit and putting it on the line in a few moments, in emergencies, as compared to the minutes or even hours required to put on similar steam capacity, also the requirements of standby and reserve capacity, we find ample justification for installing extra capacity in many hydro stations possessing adequate pondage. Such is the case with these power sites.

Duration and Load Factor Curves of Typical Load

Figure 1 (a) is a duration curve typical of the load to be supplied. At (b) are shown the kilowatt-hours contained in any segment of the peak, while curve (c) gives the load factor of any portion of the load below the peak and (d) the load factor of any portion of the load above the base.

Comparative Costs of Energy from Alternative Schemes and Projects

Figure 4 shows the costs per kilowatt-hour of the mean annual energy output obtainable from complete use of the stream flow, within the limits of plant capacities. These costs, taken from Tables II and III, cover all of the variations in plant capacity, water storage and pumping, which were considered.

Since the overall efficiency of water power generation has been assumed at only 80 per cent, and of pumping at 75 per cent and liberal contingency allowances were included in the estimated costs, it is probable that the unit costs of Tables II and III will be somewhat lowered, rather than equalled or increased, in operation.

On Fig. 4, there are also shown, for comparison, the unit costs of energy for steam stations, with coal at $1.00 and $5.00 per ton, respectively, taken from Fig. 3 of George A. Orrok's paper on The Economics of Water versus Steam Power, published in "Mechanical Engineering," December, 1929, also for a nearby steam station and a contemplated enlargement thereof.

Inspection of Fig. 4 shows that the relative energy cost of Alternative A with unregulated flow is the highest of all, though slightly less than for a nearby steam plant; however, since but little of it is firm, the greater part of its energy can compete only with energy generated at much lower steam increment cost, hence it is uneconomical.

TABLE II. A—PRINCIPAL DATA REGARDING ALTERNATIVE PROJECTS. B—INDIVIDUAL PLANT CAPACITIES

PLANTS 1-4 COMBINED

KEY NO	TOTAL CAPY. K.W.	RESERVOIR CAPY B.C.F.	PUMP CAPY. C.F.S.	MEAN ANNUAL ENERGY K.W.H.*	MIN CAPY AT 100% L.F. K.W.	MIN. WEEKLY K.W.H.*	MEAN ANNUAL LOAD FACTOR* %	COST PER K.W.H. AT SW BOARD ¢	COST PER K.W.H. AT CENTRAL POINT ¢
A	13,200	0	0	77.1	1,085	0.182	67.0	0.845	0.738
B1	40,150	2.0	0	187.5	13,925	2.00	53.0	0.515	0.611
B2	71,000	2.0	0	191.1	11,925	2.00	30.7	0.605	0.769
B3	142,000	2.0	0	194.0	11,925	2.00	15.6	0.830	0.961
C1	40,150	4.48	0	199.5	15,455	2.60	56.5	0.545	0.635
C1E	40,150	4.48	300**	222.7	17,000	2.85	63.0	* 0.555 / 0.570	0.635 / 0.650
C2	71,000	4.48	0	204.0	15,455	2.60	32.8	0.630	0.784
C2E	71,000	4.48	300**	227.2	17,000	2.85	36.6	* 0.635 / 0.650	0.773 / 0.788
C3	142,000	4.48	0	205.0	15,455	2.60	16.6	0.840	0.964
C3E	142,000	4.48	300**	228.2	17,000	2.85	18.4	* 0.830 / 0.840	0.941 / 0.951
D1	26,950	2.0	300	140.8	8,300	1.39	59.5	* 0.605 / 0.625	0.688 / 0.708
D2	53,900	4.48	1,000	199.5	15,455	2.60	42.5	* 0.640 / 0.665	0.766 / 0.791
D3	142,000	4.48	1,000	204.0	13,455	2.60	16.4	* 0.850 / 0.875	0.974 / 0.999

* { PUMPING ENERGY INCLUDED AT 0.2¢ PER K.W.H. " " " " 0.35¢ " " " "

** FOR PUMPING RUNOFF FROM 26 SQ. MI. BELOW DIVERSION DAM INTO RESERVOIR.

B. INDIVIDUAL PLANT CAPACITIES

KEY NO.	PLANT NO. 1 C.F.S.	1 K.W.	2 C.F.S.	2 K.W.	3 C.F.S.	3 K.W.	4 C.F.S.	4 K.W.
A	0	0	320	2,500	330	5,700	410	5,000
B1 - C1 - C1E	525	13,750	640	5,000	660	11,400	820	10,000
B2 - C2 - C2E	1,050	27,500	1,050	8,500	1,050	21,500	1,050	13,500
B3 - C3 - C3E	2,100	55,000	2,100	17,000	2,100	43,000	2,100	27,000
D1	525	13,750	320	2,500	330	5,700	410	5,000
D2	1,050	27,500	640	5,000	660	11,400	820	10,000
D3	2,100	55,000	2,100	17,000	2,100	43,000	2,100	27,000

NOTE:- CAPACITY AND ENERGY FIGURED AT 80% OVERALL EFFICIENCY
PUMPING EFFICIENCY ASSUMED AT 75% OVERALL FROM ORIGINAL GENERATING STATION TO WATER DELIVERED IN RESERVOIR

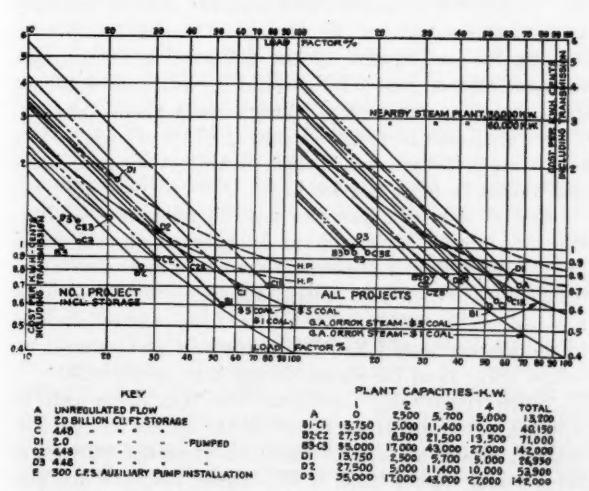

LOAD FACTOR %
NEARBY STEAM PLANT, 300,000 KW.
60,000 K.W.
COST PER K.W.H. CENTRAL POINT INCLUDING TRANSMISSION
NO. 1 PROJECT INCL. STORAGE
ALL PROJECTS
G.A. ORROK STEAM - $5 COAL
G.A. ORROK STEAM - $1 COAL
LOAD FACTOR %
KEY
A UNREGULATED FLOW
B 2.0 BILLION CU. FT. STORAGE
C 448 " " "
D1 2.0 " " " - PUMPED
D2 448 " " "
D3 448 " " "
E 300 C.F.S. AUXILIARY PUMP INSTALLATION
PLANT CAPACITIES-K.W.
A 0 2,500 5,700 5,000 13,200
B1-C1 13,750 5,000 11,400 10,000 40,150
B2-C2 27,500 8,500 21,500 13,500 71,000
B3-C3 55,000 17,000 43,000 27,000 142,000
D1 13,750 2,500 5,700 5,000 26,950
D2 27,500 5,000 11,400 10,000 53,900
D3 55,000 17,000 43,000 27,000 142,000

FIG. 4. COSTS PER KILOWATT-HOUR OF THE MEAN ANNUAL ENERGY OBTAINABLE FROM COMPLETE USE OF THE STREAM FLOW

TABLE III. PRINCIPAL DATA REGARDING ALTERNATIVE DEVELOPMENTS OF PLANT NO. 1

KEY NO.	INSTALLED CAPACITY K.W.	RESERVOIR CAPACITY B.C.F.	PUMP CAPACITY C.F.S.	MEAN ANNUAL ENERGY K.W.H.*	MIN. CAPACITY AT 100% L.F. K.W.	MIN. WEEKLY K.W.H.*	MEAN ANNUAL LOAD FACTOR %	COST PER K.W.H. AT SWITCH BOARD ¢	COST PER K.W.H. AT CENTRAL POINT ¢
B1	13,750	2.0	0	84.5	4.575	0.750	53.5	0.483	0.594
B2	27,500	2.0	0	84.5	4.575	0.750	28.7	0.597	0.819
B3	55,000	2.0	0	83.0	4.575	0.750	13.5	0.810	0.986
C1	13,750	4.48	0	74.0	8.000	1.010	61.0	0.590	0.687
C1E	13,750	4.48	883.00	97.2	8.600	1.110	80.0	* 0.605 / 0.635	0.679 / 0.709
C2	27,500	4.48	0	74.5	8.000	1.010	31.0	0.685	0.877
C2E	27,500	4.48	883.00	97.7	8.600	1.110	40.5	* 0.690 / 0.720	0.838 / 0.868
C3	55,000	4.48	0	74.5	8.000	1.010	18.4	0.875	1.011
C3E	55,000	4.48	883.00	97.7	8.600	1.110	20.2	* 0.835 / 0.860	1.222 / 1.247
D1	13,750	2.0	300	26.2	3.000	0.903	21.7	* 1.340 / 1.450	1.612 / 1.722
D2	27,500	4.48	1,000	74.0	8.000	1.010	30.7	* 0.845 / 0.910	1.039 / 1.104
D3	55,000	4.48	1,000	74.0	8.000	1.010	15.35	* 1.025 / 1.090	1.162 / 1.227

* { PUMPING ENERGY INCLUDED AT 0.2¢ PER K.W.H. " " " " 0.35¢ " " " "

** FOR PUMPING RUNOFF FROM 26 SQ. MI. BELOW DIVERSION DAM INTO RESERVOIR.

NOTE:- CAPACITY AND ENERGY FIGURED AT 80% OVERALL EFFICIENCY.
OVERALL PUMPING EFFICIENCY ASSUMED AT 75% FROM GENERATING STATION TO WATER DELIVERED IN RESERVOIR.

With respect to the entire series of projects, as well as No. 1 individually, it is clear that of the alternatives possessing storage, those bearing the key letter B, with 2.0 billion cubic feet of storage, and diversion, show slightly lower costs than the other combinations having similar total generating capacity.

Study of the costs for Plant No. 1 shows greater savings over steam costs as its capacity is increased. Transmission costs are greatest for this plant, to which the whole cost of storage, diversion and pumping is naturally also charged, when not considered in connection with the other plants. Since the storage reservoir and diversion are essential to the successful operation of the other three plants, it is proper, when considering the combined plants, to consider only the remaining costs such as pipe line, power house, units, and so on, as directly applicable to Plant No. 1. This makes it inherently the lowest cost plant of the four, and it may therefore logically be made a peak load plant, or low load factor installation. Plant No. 3 ranks next lowest in energy cost, with No. 4 ranking next, and No. 2 highest. Hence, development would naturally proceed in the order of their economy.

Provision for Installation of Additional Capacity

Provision could well be made, at all dams and in the location of pipe lines and layout of power houses, for the installation of additional capacity, up to the maximum shown in Table II, without much additional initial expenditure. Should the additional peak capacity later become desirable, it could then be readily added.

It is worth while to consider briefly the estimated costs of Plant No. 1, with varying installed capacities, storage reservoir capacities and pumped storage. Table III gives the salient figures and comparisons, with costs, where the stored water is diverted, instead of pumped into the reservoir. In this table, the key letters and numbers correspond with those of Table II. Figure 4 shows the unit energy costs and their comparison with steam power costs, as well as with the costs for the combined hydro projects.

The unit costs of energy at Plant No. 1, in cases D1, D2, and D3, compare closely with those of the series of four plants similarly designated, when taken at similar load factors. The use of pumping units operated by low cost, off-peak energy is an alternative for the diversion dam and canal of the two series B and C. That the cost of energy with pumped storage is not much greater than where the storage water is diverted, indicates that were diversion impracticable in this case, pumping would be practical and economical. It is also shown to be desirable in combination with diversion, in the cases denoted by E, where greater firm capacities and annual outputs result from pumping.

Estimated overall efficiency of the combined operation of pumping and power generation from the pumped water, from the original source of pumping energy to the generated hydro output, was taken at 0.75×0.80 equals 0.60, which is believed to be unduly conservative. It is probable that this efficiency would be found to be from 63 to 65 per cent in actual operation, thus showing greater economy for this type of operation.

Reference was made above to the possibility of constructing a low collecting dam and pumping plant as an alternative to the proposed 65-ft. diversion dam and canal. Comparative estimates of cost show that the annual cost of pumping would be approximately 25 per cent greater than for diversion. Since the annual costs of pumping against increased heads increase much less rapidly than those of dams of increased height, equality between these costs would be reached, were the diversion dam required to be but a few feet higher.

Tables II and III show two different costs for the energy delivered to the interconnected system in those cases where stored water is pumped. One figure is for the case where energy for pumping is supplied at a cost of 0.2c per kw-hr. and the other for a cost of 0.35c per kw-hr. The former contemplates the use of surplus hydro power which may at times be bought for as low as 0.1c per kw-hr. while the latter figure of 0.35c contemplates the use of increment cost surplus steam power. The latter figure is used in the comparisons, and consequently the result is believed to be conservative.

It is of interest to apply the data concerning the projected alternative developments to the load represented by Fig. 4, considered as an isolated system load.

The annual energy requirement of the system, at 40,000 kw. peak and 46.5 per cent load factor, would be 163,000,000 kw-hr. The weekly requirement, at the same peak load and load factor, is 3,900,000 kw-hr. From Table II, the following data regarding the different combination projects are abstracted:

TABLE IV

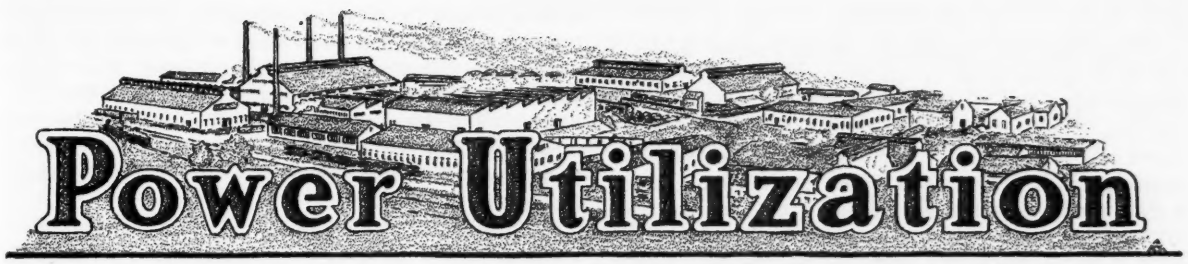
Key No.	Capacity Kw.	Mean Ann. Energy Kw-hr.[6]	Min. Weekly Kw-hr.[6]	Mean Ann. Load Factor, %	Cost per kw-hr. Delivered, c.
B1	40,150	187.5	2.00	53.0	0.611
C1	40,150	199.5	2.60	56.5	0.635
C1-E	40,150	222.7	2.85	63.0	0.650
D2	53,900	199.5	2.60	42.5	0.791
The Load.	40,000	163.0	3.90	46.5	.....

Note: The cost per kw-hr. delivered is based upon the use of surplus steam power at 0.35c per kw-hr. for pumping in cases C1-E and D2.

It is apparent that any of the projects can deliver sufficient energy, in any but a subnormal stream flow year, but that, in the minimum stream flow week, there will be a minimum shortage of 1,050,000 kw-hr. which must be made up from another source. At 100 per cent load factor, this would represent a capacity of 6250 kw., which might well be in the form of a steam station of, say, 15,000 kw. capacity, sufficient for reserve capacity against the outage of the largest of the hydro plants. Adding its cost to that of the delivered hydro energy, the unit cost, in case C1-E, would be increased 0.18c, to 0.83c, equal to the cost of energy for a steam plant at 63 per cent load factor, with coal at $1.00 per ton. Since coal costs $5.00 per ton in this locality, the competitive cost would be 0.96c per kw-hr.

Should it be necessary to sell the remaining 69,700,000 kw-hr. at 0.2c (assuming an average annual steam plant production of 10,000,000 kw-hr. to meet low water deficiencies, which is a liberal assumption) the average net cost of the 163,000,000 kw-hr. firm power delivered to the system would be 0.93c per kw-hr., which still remains lower than for steam energy with $5.00 coal.

Since remarkably uniform flow regulation can be secured, much the greater part of the excess energy can, without doubt, be sold to the interconnected utilities at rates much higher than 0.2c. These projects are economical, therefore, under the conditions prevailing in this locality.



Water Treatment for Drinking and Process Work

METHODS REQUIRED TO REMOVE OBJECTIONABLE TASTE, ODOR, COLOR, WITH TYPES OF FILTERS, SOFTENERS AND STERILIZING EQUIPMENT. BY ROLLO E. GILMORE*

DEMAND FOR palatable water keeps increasing and officials and engineers must look for new methods of treatment to produce more perfect water. As defined here, pure water contains no disease-producing bacteria nor excess of organic matter of any kind. It is bright, clear and refreshing but not necessarily distilled, as required in the medical and chemical sense, unless it is to be used for pharmaceutical manufacture. In food product or canning plants, candy or beverage manufacture and other like industries, absolute purity of water is essential to meet the rigid standard of the pure food laws, which are subject to government inspection and regulation. The testing equipment generally used consists of apparatus to test the alkalinity of water. Usually an orthotolidin apparatus is used for determining the sterile condition and bacteria content. To obtain pure water, it is generally necessary to install ultra-violet ray or ozone treatment; other successful remedies are possible but not in general use.

FILTERING SHOULD FOLLOW TREATMENT

Pure, perfect water is produced by one or a combination of the following processes. Where turbidity occurs or the color of the water is bad, suitable coagulation and filtration should be provided. Unless the suspended precipitate is removed, a water softener is of questionable value, and filtering, either with charcoal or paper discs, or treatment by ozone or violet ray does not remove bad color. The methods employed are coagulation, filtration, softening and sterilization. Often it is necessary to use both a sand and a char or paper disc filter to remove suspended matter and much of the bacteria, but sterilizing equipment should be provided by ozone, ultra-violet ray, chlorine gas, sodium hypochloride or otherwise, to destroy the remaining organisms. It is important to note that neither filtration nor sterilization alone can be depended upon to produce water satisfactorily free from pathogenic organisms, and a combination of both is recommended.

Many difficulties are found in the use of water due to suspended and dissolved impurities, the presence of which can be chemically detected and the methods for their removal then determined. For human consumption, water must be considered from a sanitary point of view and should be clear, cool, free from turbidity, color, odor or bacteria and from excessive quantities of dissolved salts. By having chemical and bacteriological examination made, conditions will be disclosed and the general nature of equipment necessary can then be determined by a consulting engineer or purification expert,

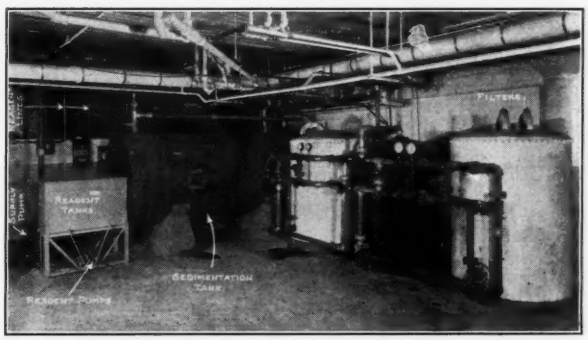


FIG. 1. WATER FILTRATION PLANT WITH CHEMICAL REAGENT PUMP, SEDIMENTATION TANK AND FILTERS

who will recommend the required equipment and treatment necessary.

COAGULATION

This is a process for agglomerating suspended particles which cause visible turbidity and which are frequently saturated with bacteria. It causes smaller particles to mass together in sizes large enough to be retained by a filter. Coagulation may be accomplished either chemically or electrically, the chemical method being to introduce one or more reagents through proportioning devices into the water preceding the filtration. The electrical method is of more recent development, said to be very effective and better where it can be used, since no chemical need be added to the water. Apparatus for the electrical method includes a chamber, passage for water through the chamber and over electrodes so arranged as to give treatment to the water in passage. The apparatus is operated automatically and so adjusted that the flow may vary with demand. Voltage may be altered to correspond with the amount of impurity and the capacity at which the plant is operated. For some waters, it is advisable to install a sedimentation or coagulation tank between the coagulant treatment and the filter to allow for the proper massing of the suspended particles. Such a plan is illustrated in Fig. 1.

*Vice-president, Chicago Association of Consulting Engineers.

Filtration

Water filters are especially desirable where water at any time shows color or becomes turbid. The prime purpose of a filter is to eliminate scale, rust, sediment and suspended matter either from raw water or water which has been treated. For household or small plant supplies, small direct water filters are available, using a char product, carbon, special stone or some patented filtering elements, without reservoirs. These usually have a small metal pot attached to the water inlet through which the water passes. The filter minerals, in addition to removing a large percentage of color, will to a certain extent remove taste from chlorinated water, but filtering material must be completely renewed when necessary as the filtering bed cannot be cleaned. A valve should be provided on the water inlet for this type filter so that water can be shut off during cleaning and renewing of filters.

For water supply to food manufacturing and larger drinking water systems, the crystal quartz and char type pressure filters are used or for some of the smaller uses

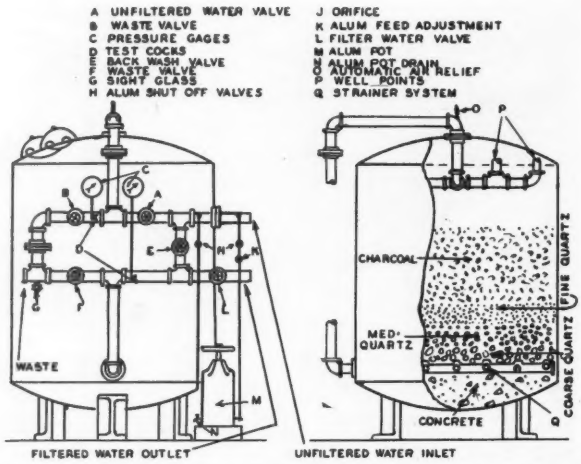


FIG. 2. CONNECTIONS AND CONSTRUCTION OF VERTICAL CHARCOAL FILTERS

paper disc filters. Crystal quartz is the standard type filter and the char types are similarly constructed except using the char instead of quartz, this char being of bone, vegetable or mineral matter.

The disc filter has a pedestal base in sizes up to 600 gal. an hour and is suitable primarily to put the finishing touch on water already comparatively clean. Interior surfaces are of either iron galvanized or brass block tinned, the shell being in two parts held together by hinged hand bolts. Filter discs are not ordinary paper but a highly compressed cotton fiber and should be replaced frequently, depending on the turbidity of the water.

Pressure filters run in sizes 12 to 96 in. diameter for the vertical, and for the horizontal, 8 ft. diameter and 8 ft. to 30 ft. in length. Equipment includes proper valves, piping, sight glass, gages, one or more coagulant feeders, and filling which is first grade quartz filter sand, washed and screened with graded gravel. The arrangement and construction are shown in Fig. 2.

Many public water supplies contain considerable percentage of phenolic compounds due to chlorinating. It is said that in the Chicago area alone in one year food products estimated at more than a half-million dollars worth were damaged through chlorophenol taste in the food. To prevent this taste some plants super-chlorinate and after a time dechlorinate with sulphur-dioxide; others use doses of ammonia or permanganate-chloride treatment, while others are using char material satisfactorily.

Following sand filtration, the filtering with char material should always be used, sometimes referred to as secondary filtration or ultrafiltration. This treatment reproduces what nature does to form brilliant spring water.

Filter Materials

Chars or carbons have long been known to possess the power of absorbing gases or removing from a solution anything present that is an impurity or differing from the main constituent to any marked degree. Various forms are the bone char, also referred to as bone black from the destructive distillation of fresh hard bones free from extraneous matter. This has usually been limited to the smaller type of household and drinking water filters.

Vegetable char comes from wood, nuts and other vegetable material, and has a hard dense characteristic. Some other types are Nuchar, made from paper mill waste liquors and said to be three times as active as the bone char and 30 times as active as bone charcoal; another is Norite, from carbonization of birchwood; Suchar is a similar product, while Carbox is made from rice hulls and still another char is made from cocoanut shells.

Mineral char is of proved worth, having high and uniform decolorizing powers. One of the mineral materials is known as Darco or Hydrodarco and is probably the most dense of all the activated chars, weighing approximately 25 lb. per cu. ft. whereas most others weigh about eight to 18 lb.

In the selection of the chars, the important thing is the density and low retention or absorption loss, based not alone on first cost but on the unit of work done per pound of carbon; also on low moisture content, mixing and revivification ability where necessary.

Activated carbons are used extensively and are classified according to use. One use is the adsorption or converting of gases and vapors, such as chlorine, hydrogen sulphide, and the like. Another is the adsorption of compounds from solutions. The majority of activated carbons contain no harmful substances and are extensively used in the treatment of the finest grades of products for foods and for medicinal purposes. Filters are also specially designed for the removal of manganese, chlorine, ammonia, chlor phenols, hydrogen sulphide and other impurities.

The hydrogen sulphide gas, which gives the objectionable odor to so-called sulphur waters, can be removed by aeration, carried out either by spraying the water through nozzles or trickling fine streams through beds of coke. Carbon dioxide can be similarly removed and oxygen can be removed by aeration when cold, spraying the water into a space under high vacuum and pumping the air released from the water out of this space.

Hard water causes innumerable troubles in commer-

cial and domestic use because of scale formed in hot water and steam pipes, boilers and heaters, the increase of soaps and chemicals where used, corresponding wear of materials in laundries, textile mills, paper mills, bleaching and dyeing works, objectionable effect on products in canneries, soft drink manufacturing plants and the like. When used for ice manufacturing, hard water prevents the formation of clear ice and increases cost of production, white ice or rust often being encountered. Such salts can be precipitated from the water best by the lime-soda process.

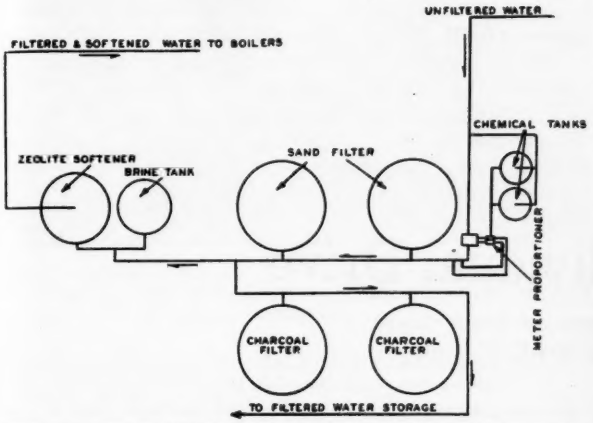


FIG. 3. DIAGRAM OF WATER TREATING EQUIPMENT LAYOUT FOR FOOD PRODUCTS PLANT

Softening of water is desirable in manufacture of food products and especially for vegetables such as peas and beans, where a distinct improvement is made in flavor and color. By eliminating the hardening salts of calcium and magnesium, the natural flavor is retained and the market value enhanced. Similarly in tanneries, paper and chemical plants softened water improves products, eliminates hazards, reduces costs, speeds up production and allows equipment to stay in service longer with lower upkeep cost.

For laundries, softening of water has been known to reduce the consumption of washroom supplies 40 to 70 per cent, improves the quality of the work, increases the life of fabrics and leaves a higher luster. It also reduces replacements from 20 to 40 per cent.

In textile mills, similar advantages are found, raw wool, cloth, cotton fabrics, silks and rayons benefiting immensely. Materials that are to be dyed will take color more uniformly where soft water is used, because of the freedom from calcium or magnesium salt deposits and curds after washing. Arrangement for such a plant is shown in Fig. 3.

Zeolite

One medium used for removing calcium and magnesium in water is zeolite, of which two types are available for softening, namely the natural mineral, also referred to as green sand zeolite, and the synthetic or manufactured zeolite. The green sand is a natural aluminum silicate, dark green in color and of crystalline formation, similar to coarse sand. It is obtained by mining. The synthetic zeolite is more porous and manufacturers claim that a pound will soften as much as four pounds of green sand.

Water is simply permitted to pass through the mineral as it is placed in the tank and, when the capacity for absorption of hardness is reached, the mineral is regenerated by washing with salt water. Some kind of signal is usually provided to warn the operator when regeneration is required.

Lime-Soda

This type of softener consists of either wood, steel or concrete sedimentation tanks, operated from the top or from the ground and may be arranged for various degrees of automatic operation. For industrial purposes, the cold-process type is usually used but for boiler feedwater, the hot-flow process is more rapid and often preferred.

Softening may be intermittent, the softener having two or more settling tanks, one being filled and treated while the other is used to deliver treated water to service. In this way, each tank goes through the cycle of filling, charging, agitating, settling and emptying.

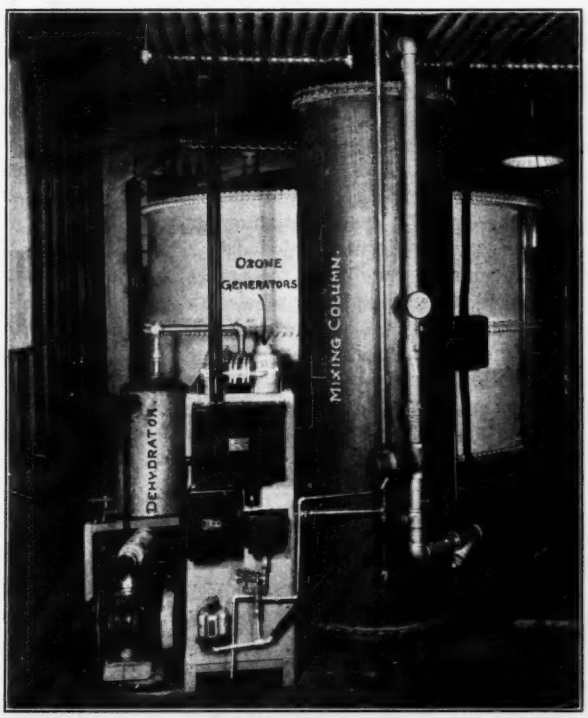


FIG. 4. ARRANGEMENT OF OZONE STERILIZING PLANT FOR WATER TREATMENT

For continuous softening, there is a single tank through which the water flows from inlet to outlet, receiving the chemical charge at the inlet, the precipitate settling as the water flows through and after filtering the water leaves the outlet completely treated.

Sterilizing

Ultra-violet light water treatment has been found extremely destructive to bacteria but should be used after turbidity is entirely removed and the water filtered. Action of ultra-violet light is similar to that of sunlight in killing bacteria. An arc between metal electrodes gives a light rich in ultra--violet rays that will

produce more rapid sterilization than that obtained by sun rays. In the mercury vapor lamp system, the lamp is enclosed in a quartz container and so arranged that a thin sheet of water passes through the compartments near the lamp several times thus being subjected to the rays. But a few seconds exposure to these rays is fatal to all bacteria. Temperature of the water has little or no influence but turbidity or suspended matter in the water must be removed before treatment. Odor and disagreeable taste from chemicals are not removed by the ultra-violet treatment.

Ozone treatment of water, properly applied, produces a potable water complying with all laws and removes both the odor and taste. It has been demonstrated that only a small quantity of ozone is required to eliminate the most marked taste and odors. Ozone removes 98 per cent of the dissolved organic matter, pathogenic bacteria, has no byproducts of reaction and uses no chemicals.

Ozone is produced by subjecting dry air to electrical discharges of relatively high potential, sufficient to cause the breaking up of normal oxygen structure and regrouping in a new form, termed ozone. The ozonized air is forced in the form of minute bubbles into the water to oxidize or burn the minute organisms. Amount of ozone required and the time taken to sterilize the water will depend on the condition of the water, the presence of iron and organic matter requiring use of more ozone. These can best be taken care of by filtering prior to sterilization. An ozone outfit for sterilizing is shown in Fig. 4.

Liquid chlorine is employed for sterilization of public water supplies to eliminate disease-producing bacteria, especially those responsible for typhoid fever. Taste is, however, left in the water and this prevents it from being extensively used in most of the manufacturing plants making food products and subject to the United States Pure Food Laws.

Group vs. Individual Drive

Requirements Depend on Speed, Load and Use Conditions. By C. W. Drake*

INTRODUCTION of electric motors and electric transmission removed the limitation formerly imposed upon the size of a manufacturing plant by the amount of power that could be developed by a certain waterfall or that could be distributed mechanically from a central source. With ample supply of electric energy available, regardless of source, there was no limitation to plant location, size or arrangement of buildings. But, inside each building and on each floor of each building, the question was how much to cut up or eliminate line shafting and belts in order best to utilize electric motor drive. Discussions of this question have continued to the present day.

Continuous Process and Steady Load

To the casual observer, the drives in a flour mill appear not materially different now when using electric power from what they did when using water or steam power many years ago. We find perhaps five or six floors crowded full of machinery with barely space to walk around, a network of shafts and belts, all connected to one or more main drives on the first floor. Such drives may take all the way from 100 hp. to 1000 hp. or over, depending on the capacity of the mill. We may ask why do such conditions exist or persist? Let us examine the process and machines used.

Unlike many industries, there is no storage capacity from the time the wheat enters the first rolls until the flour is completely milled. The output of one machine is the feed or supply for the next and the shutting down of one elevator or conveyor in the chain interrupts the entire process. With the machinery grouped as closely as possible, Fig. 1, with the necessity of having all machines operating all the time, what can be saved by individual or even by small group drives? It is doubtful whether any shafting or belting could be saved in a well-designed mill and it might be possible that additional counter-shafts and belts would be required in some cases to reduce from motor speed to that of the line shaft, which is often quite low.

*General Engineering Dept., Westinghouse Electric and Manufacturing Co.

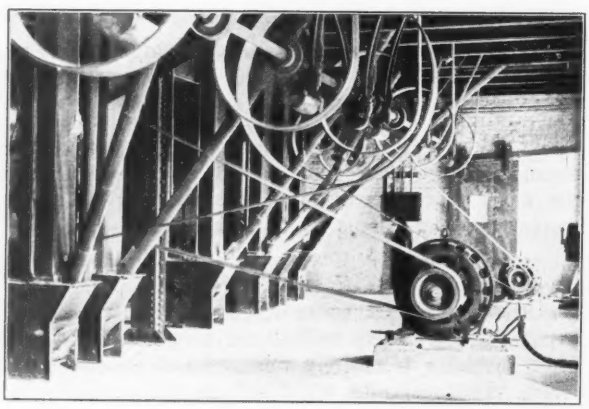


FIG. 1. FLOUR MILL DRIVE CALLS FOR SLOW SPEED SHAFTING OPERATING CONTINUOUSLY

Large Units and Intermittent Operation

In connection with each flour mill is a wheat receiving and cleaning department, which in old mills was generally driven by a separate prime mover because the operation of this department had no direct connection with that of the mill itself. Instead of a large number of small machines are a few large units such as bucket elevators, belt conveyors, separators, Fig. 2, cleaners, which may be used in various combinations at various times and only for a few hours a day. Consequently, with individual drive a large amount of shafting and belting is saved in the original installation and when operating it is necessary to run only the few machines desired, thus saving large friction losses and making a

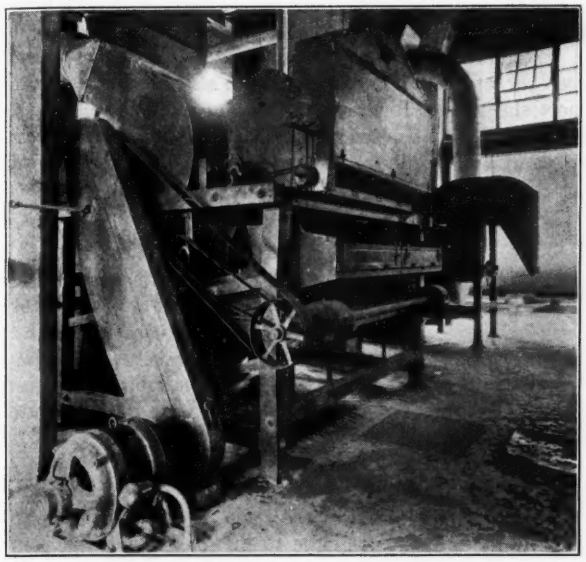


FIG. 2. RECEIVING SEPARATOR WITH INDIVIDUAL DRIVE SAVES SHAFTS AND BELTING, ALSO PERMITS OF ANY LOCATION

marked saving in the total power consumption and also in the maintenance of transmission equipment.

Wood Working Uses High-Speed Machines Irregularly and Independently

In the wood-working industry, manufacturing conditions are quite different, since the operation of one machine seldom depends upon another and there is considerable storage on trucks and benches, between the various operations. Wood-working machines operate at high speed, consequently are readily coupled or belted to high-speed motors, making compact and economical units. It is, therefore, natural that individual drive has made rapid progress in this industry.

On the other hand, there still may be cases where a group drive is quite satisfactory. Consider for instance, the small builder's finish or cabinet shop which has been in operation for many years, with only a few men employed sometimes at the bench and again first on one machine and then on another. A single motor of small capacity, as for instance 7½ hp., may drive a large number of machines, Fig. 3, due to the low load or diversity factor. Even then, the motor may be shut down for a considerable part of the time. In a new layout, even under the operating conditions stated, individual drive would probably prove most economical.

It takes little imagination to picture three motors driving the two trimmer saws and freight elevator eliminating the overhead shafting, the counter shafts on the floor and the twisted belts for the elevator. Not only would this result in quite a power saving, since this is a mill with a standard production, but the movement of trucks and handling of material would be greatly facilitated.

In buildings having high ceilings or roof girders, line shaft drive, except along the walls, involves the construction of elaborate structures which, besides taking large space and interfering with the operation of means and the handling of material are quite expensive to construct.

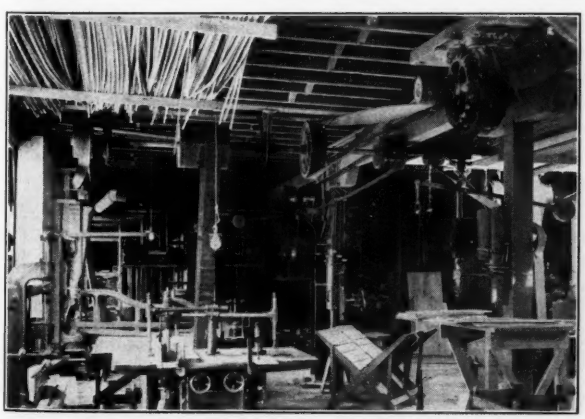


FIG. 3. FOR SMALL WOOD SHOPS, GROUP DRIVE MAY SERVE

Paper Making Calls for Exact Speed

In paper mills, the driving of the paper machine itself constitutes a more difficult and complicated problem than is met with in almost any other industry. Consisting of a number of independent sections over which the paper in its various stages of formation must pass, a very exact speed ratio must be maintained in order not to break the sheet of paper. A quite natural solution to the problem was to run a line shaft the entire length of the machine and belt from this to each section, through taper cone pulleys for close speed adjustment, to bevel and spur gears so as to obtain the desired speeds for the various sections.

Figure 4 shows such a drive in the basement of a mill with the belts going up to the gear stands above. This particular machine was driven by a variable speed steam engine but a steam turbine with gear reduction could be used, or, as is more frequently the case, a direct-current motor supplied with variable voltage from a motor-generator set.

With the increasing demand for larger paper machines, more speed and more power, the mechanical problems became more and more difficult and the ad-

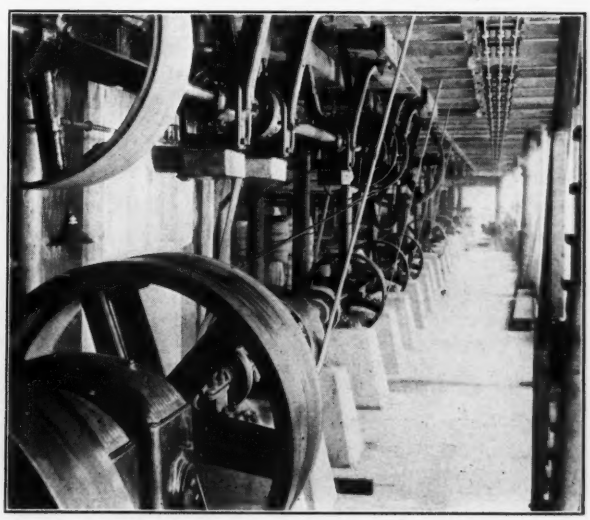


FIG. 4. DRIVE SHAFT FOR BELTED PAPER MACHINE

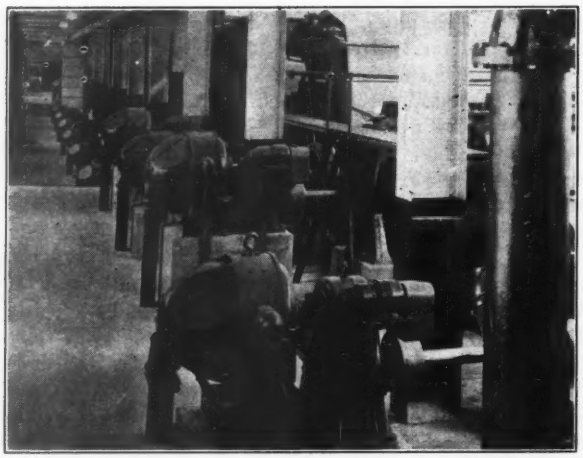


FIG. 5. MOTOR DRIVE IS PROVIDED FOR EACH SECTION OF THIS PAPER MACHINE

vantages of individual or sectional motor drive became apparent. Figure 5 shows such a drive on a paper machine. The basement is entirely clear of shafting, each motor driving its respective section through a self-contained gear reducer, which insures a minimum amount of attention and maintenance with a maximum reliability and safety. Motors are totally enclosed, with forced ventilation, which insures maximum protection against water, steam and mechanical injury. Automatic regulation maintains the correct relative speed on all sections at any desired paper speed, giving operating advantages which are responsible for the rapidly increasing use of this type of drive.

Even Several Built-In Motors May Be Used

As an interesting example of the present tendency to built-in motors, Fig. 6, shows a moulder with induction motors direct connected to each cutting head, both horizontal and vertical and a multi-speed induction motor used for the feed mechanism.

For shaper spindles, which run at higher speeds than can be obtained on 60-cycle induction motors (3600 r.p.m. maximum), it became necessary to supply direct-connected, built-in motors with a higher frequency, which in that case was 120 cycles to give a speed of approximately 7000 r.p.m. Induction frequency changers are available in various capacities and for various frequencies, so that direct-connected or built-in motors may be used to meet nearly any cutting speed required.

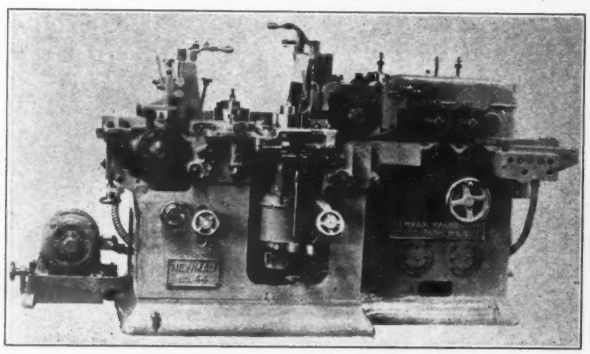


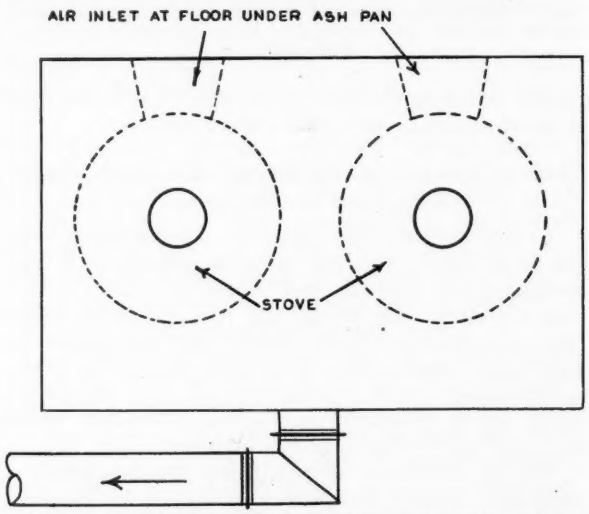
FIG. 6. MOTORS ARE HERE BUILT IN TO DRIVE EACH PART OF THE MOULDER

Examples of group and individual drive discussed are characteristic of many found in other industries and show the reason for the existence of each type. Each case must be considered on its own economic merits since so many variables are involved. What might be good practice in one mill would be questionable in another.

Warm Air for Ice Cans

In a low-pressure ice system, there was great difficulty in keeping the air tubes which were of the center drop style, from freezing up in the winter months, thereby stopping the flow of air into the ice cans during the freezing period. No steam was available, as Diesel engines were used; also, the ice tanks were in a separate building from the engine room.

Some means had to be devised for giving a free air passage during the entire freezing period. As we were using a large stove to heat the room, it occurred to me to install another stove as close to this one as possible and



HOUSED-IN STOVES WARM AIR FOR AGITATION IN ICE CANS

then build a sheet iron housing of 10-gage iron around the two, drawing the air in from the front underneath the ash pan and feeding the blowers from the back near the top. This has been in use now for nearly 3 yr. and works perfectly. We have no frozen tubes, our ice is always uniform and the cost of operating these stoves is very small. At the same time, it helps to warm up the entire tank room of 1600 300-lb. cans. The temperature can be carried at any temperature desired but we find air to enter the blowers at 80 deg. F. or above is about right.

As shown, an 8-in. pipe from near the top of the casing feeds the blowers, with shut-off valve. Sheet metal boxes in front of coal and ash doors keep smoke and soot from mixing with air to the blowers. The same arrangement could be used for warming air for any other purpose.

Kansas City, Kan. J. F. Staley.

Combination fuel oil, gas and pulverized coal burners have been developed.

Unit Heaters and Heating Economy

Types of Heaters
Proper Application
Laws of Air Flow

By C. D. Graham *

Floor-Mounted Units Give Quick Heating in Hangars and Garages After Doors Have Been Opened

ECONOMIC UTILIZATION of heat energy generated in the power plant is of vital importance. Inefficient heating is reflected in the price of any manufactured product, since the fuel bill is chargeable against manufacturing overhead. The realization of this fact has created the great demand for unit heaters.

Laws of Air Flow

Discussion of the unit method of heating should start with a statement of the fundamental laws, which are:

I. Heated air rises, if uncontrolled, stratifying according to temperature. Nature resists the movement of heated air downward, through cooler strata, or cool air upward, through warmer strata.

II. Air is most easily moved horizontally within its own temperature level.

These two laws are aptly termed the natural laws of heating. To make the most efficient use of fuel, heating equipment must be designed with these two basic laws in mind.

It would be difficult to find anyone unfamiliar, at least in a general way, with the first law. For instance, no one would think of placing a warm air furnace in the attic and expect it to heat the building.

To the casual observer, the second law is not so apparent and a thorough understanding of the first law is essential to the comprehension of the second. For example, it is an established fact that warm air tends to rise, since it is less dense than cooler air. This being true, it follows that, if air in any inclosure has a variation in temperature, the warmer will be at the top and the cooler air at the bottom. Between these two extremes will be a multitude of strata of slightly varying temperatures, graduating from cool air at the floor line to warm air at the ceiling. Assuming that the inclosure under consideration is 20 ft. high and that air is being exhausted from the 10-ft. level, the air would flow most readily from the strata at the 10-ft. level, since the warmer air above would not of its own accord drop to a lower level nor would the cooler air below, rise. Of course, while the air of the 10-ft. strata is being exhausted, other air will move in to take its place. Similarly, if a fan is recirculating within an inclosure and discharging horizontally, the air stream will carry

*Manager, York Heating and Ventilating Corp.

FIG. 1. 8 FLOOR-MOUNTED UNITS HEAT LARGE ARMORY

farther (with a given impulse or velocity) than when discharging at an angle upward or downward.

Air Distribution

How, then, should these natural laws be applied to unit heater design? Since heated air rises if uncontrolled (Law I), the first thing to be considered is ways and means of controlling the air discharge. So far, only two ways of governing the air discharge stream have been found. One is to give the heated air sufficient impulse (velocity) to prevent it from rising rapidly to the ceiling or roof. This high velocity has a secondary action of equal importance, its induction effect, which puts into circulation a large volume of the surrounding room air, which mixes with the discharge stream, thereby reducing its temperature so that the air stream has less tendency to rise. The other method of controlling the heated air discharge is to limit its temperature so that it will be less buoyant and therefore have less stack effect.

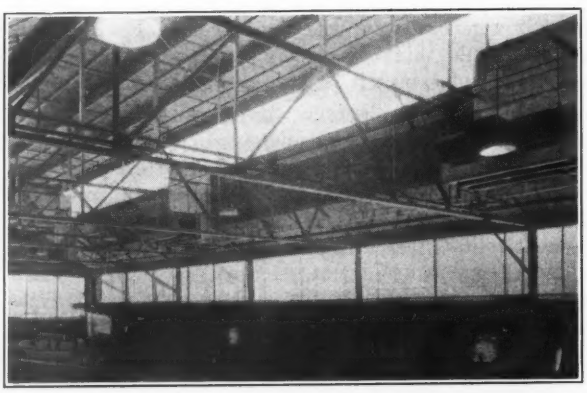


FIG. 2. HIGH-VELOCITY SUSPENDED UNIT DRAWING ALL AIR FROM OUTSIDE

In unit heater design, the trend is toward lower final temperatures. At present, it is not considered good practice, from the viewpoint of fuel economy, to discharge air at more than 70 deg. above room temperature. It is the writer's opinion that a few years hence unit heaters having final temperatures of more than 40 or 50 deg. above room temperatures will be considered relatively uneconomical of fuel.

Unit Heater Location

Now, for the application of the second law. Since air is most easily moved horizontally within its own temperature level, any recirculating unit heater removes air from the level of its intake. If the intake is at the floor level, the cooler air at that level is removed, heated while passing through the unit, and discharged overhead. Warm air from above moves in to take the place of the air removed, since a vacuum cannot be maintained in an open room. Thus the principal circulation of warm air is in the working zone and the minimum of heat escapes to the ceiling or roof.

If the heater intake is overhead, the air handled by the unit is necessarily drawn from overhead. The air at or near the floor line is not disturbed (heated) unless the air discharge is directed toward the floor with sufficient velocity to penetrate the cooler strata below.

Heater Capacity

Any room can be heated, regardless of the method used, if enough heat is supplied. The big mistake frequently made by plant executives not familiar with heating is in purchasing heating equipment on its heat output without considerating how efficiently it will distribute this heat. Take for example two unit heaters of the same rated capacity. Assume that unit A has a final temperature of 160 deg. with 60 deg. entering air temperature, while unit B has a final temperature of 110 deg. with 60 deg. entering air temperature. Unit B will handle twice the volume of air handled by unit A, since its temperature rise is half that of unit A. Many plant owners or architects would consider these two units equal and would purchase on strictly a price basis unless they considered the material and workmanship in one unit superior to the other.

From the viewpoint of economy, these two units are unequal. The high final temperature and low air quantity combination gives an excessive stack effect, resulting in extremely high ceiling or roof temperatures. The other unit with its large volume of air at a considerably lower final temperature distributes its heat much more efficiently. This is especially true if the discharge velocity is high. Unit A, with its high final temperature and lower air quantity, would require easily 25 per cent more fuel in order to maintain the same working zone temperature than unit B.

It is more foolish to buy heating equipment on its price per 1000 B.t.u. than it is to purchase coal on its price per ton, disregarding its heat value.

Types of Heaters

Four major types of unit heaters are made. First, high-velocity floor mounted; second, high-velocity suspended; third, low-velocity floor mounted; fourth, low-velocity suspended. Some engineers carry the classification still farther and divide any or all of the above four major types into draw-through and blow-through designs. This subdivision is, however, a mere detail of construction and need not enter into this discussion. It is impossible to set definite limits on air velocities but, in general, 1500 ft. per min. and above is considered high velocity, 800 ft. per min. and less, low velocity. The range of velocities between 800 and 1500 ft. per min. is indeterminate, the term most generally applied being "intermediate" velocities.

From the foregoing discussion, it is obvious that the high-discharge-velocity, floor-mounted unit heater makes the best use of the natural laws. It removes the cool air from the floor line, discharges it at a high velocity in a horizontal plane, just above the head line and, when properly designed, has a reasonably low final temperature. With its high velocity, it has the further advantage of being able to distribute heat over a wide area, Fig. 1, and the induction effect places in circulation a volume of room air more than equal that handled by the unit, thereby reducing stratification to the minimum.

Applications of Types of Unit Heaters

The high-velocity suspended unit, Fig. 2, has all the advantages of the high-velocity floor-mounted unit except that it does not withdraw the cooler air from the floor line, consequently is not as economical of fuel.

The primary circulation takes place above the working zone, unless the heated air is discharged downward with sufficient velocity to stir up the air at the floor line. In many cases, workmen object to the warm blasts and it is then necessary to adjust the angle of discharge so that the velocity is spent at a point just above the head line. The addition of a recirculating duct extended to within one or two feet of the floor makes the suspended unit a floor-mounted unit for all practical purposes.

From the standpoint of fuel consumption, the low-velocity floor-mounted unit is less efficient since its velocity is too low for a marked induction effect, consequently the warm air stream rises rapidly. It does, however, remove the cooler air from the floor line. The low-velocity suspended unit makes little or no use of the natural laws and, from the standpoint of fuel economy, is the least efficient type. There are, however, certain applications for which this type of unit is admirably suited. These will be pointed out later.

In an otherwise quiet room, practically all unit heaters make some noise, due to the sound of the air passing through the coils, fans, and outlets. This noise is not great and, in the average busy plant, it is entirely lost among other sounds.

Where noise has no consideration, the high-discharge-velocity, floor-mounted unit should be used, because of its greater fuel economy. Practically any make of high-velocity, floor-mounted unit is available in relatively large sizes, which means an installation saving, in that there will be less piping, fewer valves and fittings and less electrical wiring required.

Low and intermediate velocity, floor-mounted units, Fig. 3, are, on account of their lower outlet velocity, quieter. They are properly used in small rooms where the blows are relatively short. They are also the proper selection for that vast field of semi-quiet operation, such as garage workrooms, where the mechanics tuning motors must listen for faint sounds, or rooms from which noisy equipment is absent and the employes work at light, noiseless tasks. In such applications, quietness is frequently of more importance than fuel economy, although a high degree of the latter may be obtained by the use of units having low discharge air temperature when compared with older forms of heating.

The low-velocity suspended unit has a wide variety of uses. It is frequently placed in some rooms such as factory offices and toilets. The heat losses from such rooms are usually small compared with the losses from the main part of the factory and the fact that these units require more steam to maintain a given breathing zone temperature has, therefore, little bearing on the overall efficiency of the plant.

In multi-story buildings, where the ceiling heights are usually low and all of the heat losses are in the side walls, low-velocity suspended units at times make a better layout than high-velocity units. The decision between these two types hinges upon a number of variables, among which are building proportions and the manner in which materials are stored within the building. When low-velocity suspended units are used, they should be placed at frequent intervals, blanketing the exposures.

Where the greatest heat is required at or near the ceiling or roof and a comfortable working-zone temperature is not required, a low-velocity suspended unit is ideal. An example of such a use is warehouses, where heat is required only to prevent the freezing of sprinkler systems. For this service, deflectors should not be used. Another application for these units is the clearing up of localized ceiling or roof condensation caused by escaping process steam.

Aside from fuel consumption, an item to be considered on suspended units is their inaccessible location. Since it is difficult to get maintenance men to give equipment located at or near the floor proper attention, it is only to be expected that unit heaters suspended high overhead will be neglected. For this reason, suspended units usually have a shorter life than floor-mounted units.

Temperature Control

One advantage common to all unit heaters is the ease with which temperature may be regulated. For

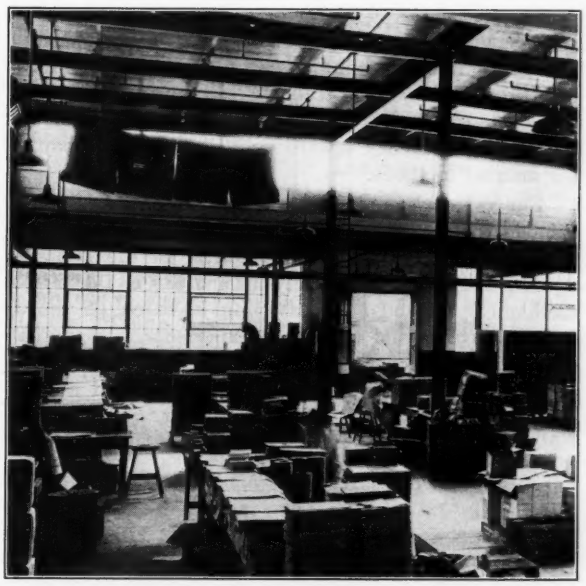


FIG. 3. FLOOR MOUNTED UNITS FOR LOW AND INTERMEDIATE VELOCITY

installations requiring extreme evenness of temperature, thermostatic control of the amount of steam admitted to the coil is advisable. On the majority of industrial jobs, however, the usual method is to place a thermostat in a remote location from the heater, which thermostat electrically stops or starts the fan or fans as the temperature rises above or falls below a predetermined point.

In conclusion, let it be clearly understood that no one type of unit is proper for all heating problems. The purchaser or his engineer should examine the conditions of his particular job and select equipment accordingly. Frequently, several types of units should be used on one installation in order to get the best results.

With the keen competition of today, everyone must see that production costs are held to the minimum. As stated previously, plant heating is truly chargeable to production. Without proper heat, workmen will waste valuable time trying to keep warm and, even though a plant be adequately but inefficiently heated, the additional fuel required is reflected in the price of the product manufactured.

Steam Jet Conveyors for Ash Removal

IN THESE DAYS of high efficiencies as applied to boilers, stokers and pulverizers, it is indeed logical that coal and ash handling equipment should be given similarly careful attention. The trend in this direction has been noticeable particularly during the last 10 yr. as part of the general tendency toward substitution of mechanical for manual methods.

For this reason, W. W. Sayers deserves to be commended for his effort in presenting the various methods applicable to coal and ash handling in the issues of April 1 and 15. Undoubtedly his analysis of the various mechanical methods of conveying is based on mostly careful theories and up-to-date experience. In the case of steam-jet ash conveyors, however, his references do not indicate acquaintance with their advanced applications. A contradiction admitted by Mr. Sayers, to the logical advantage of any equipment that will take up less space than other similar equipment for the same function or performance appears in his statement that "the steam jet is especially well adapted where the ash must travel a tortuous path and where there is little space for other types of equipment."

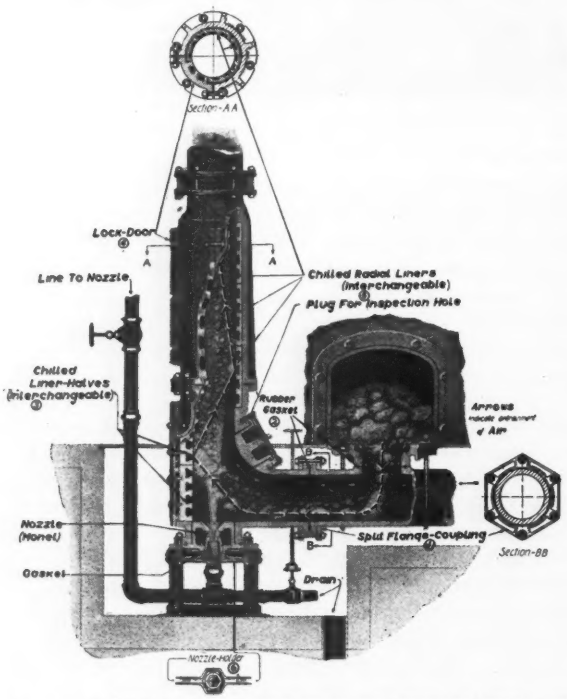


FIG. 1. TYPICAL ARRANGEMENT OF STEAM JET ASH CONVEYOR SHOWING PATH OF CLINKERS, ACCESSIBILITY OF LINERS, AND ARRANGEMENT OF NOZZLE

Were it true that this advantage of less space is offset by the excessive steam consumption and maintenance of a good steam-jet ash conveyor, then this apparent contradiction would be excusable. Just as the principal components of the belt conveyor, however, have been greatly improved in the last five years, according to Mr. Sayers, so the steam-jet ash conveyors have improved considerably over the crude types of yore. As an evidence of this, we reproduce here two illustrations of the most important parts of such conveyors, which are known as elbow-sets. Comparison of these with corresponding parts of earlier steam-jet conveyors will show an interesting story of development.

Wear at the elbows and of pipe sections beyond and adjoining the elbows has in the past accounted, not only for excessive cost of maintenance but for the great inconvenience caused by shut-downs of the conveyor for replacing elbows and pipe sections. Good steam-jet conveyors today are protected with liners for a sufficient distance beyond the elbows so that the wear due to the inevitable rebounding of clinkers is borne by liners, which are made readily accessible, instead of by pipe-sections, the replacement of which were costly and laborious. Also, the wear-resisting qualities of the liners have been greatly improved. Metallurgical developments have produced harder castings and deeper chills, while on the other hand abrasives, like corundum, imbedded in the wearing surfaces of liners, have given them much longer life.

Following advances made in the design of steam turbine nozzles and in the use of special alloys that resist successfully the wiredrawing action of high-pressure steam, nozzles that produce air currents of high velocities in conveyors have been produced and steam consumption of conveyors fitted with them has been reduced. In order that these nozzles may be checked frequently, the designs were required to permit convenient removal as shown in the illustrations.

Remarkable reductions in steam consumption have been due, furthermore, to better appreciation of the correct principles as applied to layouts of these conveyors. Thus reductions in steam consumption of as high as 50 per cent have been achieved over improper layouts under

identical circumstances. Part of this reduction was due to such improved joints between the component parts of the conveyor, that remain air-tight under all conditions, as shown in Fig. 1.

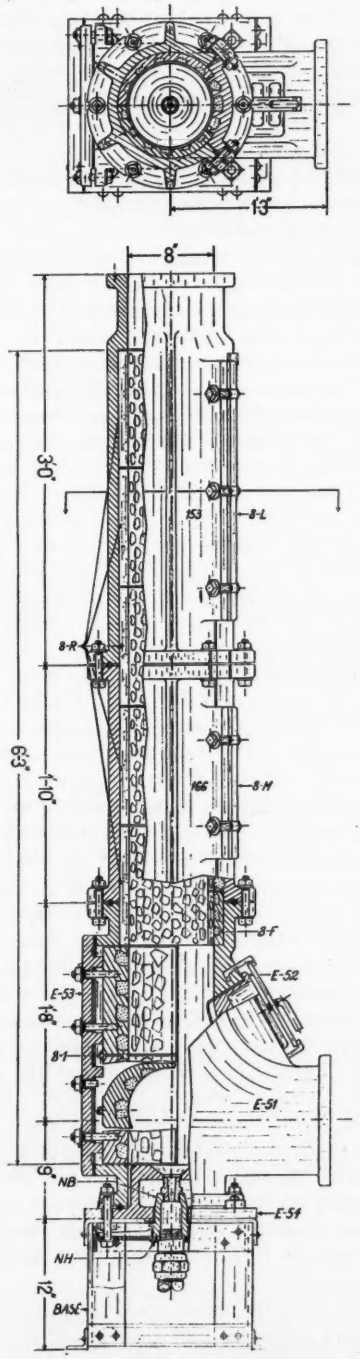


FIG. 2. JET-ELBOW SET FOR STEAM JET ASH CONVEYOR SHOWING CORUNDUM INSERT LINING

Problems of dust and noise, so detrimental to early steam jet conveyors, have also been solved so that no longer are objections raised against these conveyors along these lines.

Mr. Sayers states very properly, "Every tool is best suited for certain conditions." Accordingly, from the view point of durability, the logic of using a conveyor that is made of hard cast-iron pipe sections of ¾-in. and 1-in. wall-thicknesses and of heavily reinforced elbows and fittings, is difficult to dispute, for the handling of ash that is considerably more destructive to other materials than to cast iron. The abrasive action of ash is typical and it becomes corrosive as soon as it is quenched. Naturally both the convenience in space and the advantage of durability of steam-jet conveyors would be offset without their economy in steam consumption and maintenance. The latter, however, have been sufficiently proved and established to make the steam-jet conveyor the preferred type for a far greater variety of cases than would have been the case years ago. This applies particularly to powdered coal burning boilers because of the greatly reduced quantity of recovered ash.

Easton, Pa. EUGENE HAHN.

Voltage Regulator Maintenance

AFTER A VOLTAGE regulator is put properly into operation, little maintenance is necessary. This often results in neglecting the regulators altogether. Longer life and better operation can be obtained by periodic attention. The relay contacts that operate directly across the exciter rheostat should receive the most attention. These should be inspected once a week or once a month as experience dictates. The distance between relay contacts when open should be 1/32 inch. The surface of these contacts can be kept in good condition by passing a magneto file between them after the regulator is cut out of service. A magneto file has a double cutting edge and is approximately 1/32 inch thick and can be purchased in almost any hardware store. The life of the contacts is also increased by reversing their polarity by means of the reversing switches at the bottom of the regulators. These switches should be reversed at least once every 24 hr. This can be done readily without cutting the regulator out of service.

The main contacts are composed of a special metal which is very hard and needs attention semi-annually. To dress these contacts, they should be removed from the regulator and honed on a stone by hand until the slight cavities are removed. They should then be replaced in the regulator and set according to gage.

The life of the bearings and pivots will be greatly increased if each bearing is oiled once every six months with a drop of light lubricating oil. A good method is to dip a slender stick or quill in oil and to touch it to each pivot point. In the semi-annual inspection all fastening including all nuts, screws, should be examined to assure tightness.

Hobart, Ind. H. J. ACHEE.

Homemade Valve Seat Grinder

NOT EVERY POWER PLANT includes in its repair outfit, equipment for regrinding the flat seats in globe, angle and check valves, although it is a serious oversight not to do so.

An efficient valve seat grinder for any sized valve of the designs mentioned may be made easily, after removing the composition disc from the valve body, by making a thick mixture of emery powder and shellac and filling up the empty disc holder with the mixture.

After this has been set aside to harden, the surface may then be smoothed off and the stem and holder rotated with a brace thus refacing the valve seat. It is then a simple matter to remove the shellac mixture by slight heating.

A better plan is to use the holders and stems from discarded valves of different sizes and have the disc holders filled with the hardened mixture ready to use at a moment's notice. If the valve seats are badly worn, you can have some of the old disc holders filled with a coarse emery powder mixture to do the first cutting and others with fine emery mixture to do the finishing.

Lakeview, Ont., Can. JAMES E. NOBLE.

Now's a Good Time to Repair Stacks

PROBABLY well over 50,000 steel stacks are in service throughout the country, ranging in size from enormous steel self-supporting stacks of the central station companies, down to the thin sheet steel guyed stack of the small laundry, or sand and gravel plant with its 25-hp. boiler. Every steel stack that is not properly inspected and maintained is a hazard, for all of them are subject to corrosion that may weaken the guy wires or the supports at the base. Moreover, corrosion may also get in its deadly work anywhere between the top and the base. Inspection is the only way to determine the condition of the steel stack and the ideal time to make such inspection is in the summer.

The fact that inspection can be made and repairs and repainting carried out most conveniently during the summer months makes this subject of more than ordinary importance at this time. A stack subjected to a superficial inspection of the exterior may indicate apparently satisfactory conditions. When, however, scrutinized closely by a conscientious man traveling around and up the stack foot by foot, it may be found that this disintegration has proceeded rapidly and expensively. Inspection should, of course, be made of the interior as well as of the exterior. Whether corrosion takes place on the inside or outside depends largely upon atmospheric conditions as well as operating conditions; and a stack may be free from corrosion on the inside and yet badly corroded on the outside and vice versa.

In many instances, the exterior of a stack is inspected, while the interior is ignored altogether. This sort of inspection is not sufficient, because in the majority of cases interior corrosion tends to be more rapid and pronounced than that taking place on the outside.

Corrosion of the outside of a stack is due in part to the elements and the acids and sulphur fumes of combustion that attack steel quite rapidly in the presence of moisture. Prevention is a comparatively simple matter and one which is not really expensive. The remedy is to paint the steel with a paint that is acid and moisture proof, that can expand and contract with the surface it covers, that will not peel or blister due to heating of the stack.

Painting should be done carefully and conscientiously, using not less than two coats, otherwise pin-hole abrasions may occur and the paint fail to give complete protection. Painting should be done regularly to obtain the full benefits of the painting, the frequency depending of course upon local conditions. Every 2 yr. seems to fulfill all requirements for average cases.

It is more difficult to prevent corrosion on the interior of a stack; and it will cost more than for protecting the outside because on the inside the hot flue gases have to be contended with. These gases are extremely corrosive, causing rapid disintegration of the steel if means are not taken to prevent them from doing so. This corrosion is due, primarily, to moisture in the flue gases. This moisture condenses against the comparatively cool walls of the metal stack, the condensate thus precipitated consisting largely of sulphurous acid. Carbon dioxide gas is always present and attacks steel in the presence of moisture.

Preventing corrosion on the interior of a stack requires that the metallic wall of the stack be protected from the acids and gases by lining with fire brick. This lining should be carefully laid, particular care being taken that no air gaps are allowed to exist between the lining and the metallic wall, otherwise the corrosion will take place as fast, if not faster, than where no lining is used. The intervening space between brick and metal should be filled in completely by grouting with cement. Experience has proved that the upper rings corrode faster than the lower, due no doubt to the greater condensation at the top of the stack, consequently the lining should go the full height of the stack.

Keeping an unlined stack out of service from time to time, even for short periods, is probably more conducive to corrosion than anything else. A stack which is properly lined is able to stand idle, little affected by corrosion, whereas an unlined stack will probably suffer seriously. A lining is a great advantage, therefore, for plants that may operate only from time to time instead of continuously. Another advantage of lining a stack, besides that of protection, which prolongs its life, is that the radiation losses through the metallic walls are materially reduced, thus improving the draft.

Outward appearance of a stack is no indication of its true condition. The exterior may appear in first-class condition while the interior may have corroded to the danger point; while inspection is being made, it is extremely important to inspect the guy wires in cases of guyed stacks. Corrosion must be looked for. In some cases, as the stack had swayed in the wind, strands of guy wire have become worn so that the strength of the guys is more imaginary than real. It might be pointed out, also, that in many instances guy wires become charged with electricity, so that they should be handled with the utmost care against electric shock. Men mounting stacks should go cautiously as cases with serious consequences have been known where the plate or sheets were so badly corroded they were unable to support a man's weight.

The fact that the steel stack is standing and that it is not easily inspected and gives practically no trouble means that, ordinarily, it will be left alone. Corrosion that goes on unseen is all the more dangerous because it is unsuspected. A stack that falls may not only shut down a plant but may spread havoc, loss and injury broadcast on the streets below. The summer months are the months when inspections can be made and when painting and repairs can be most effectively and most inexpensively carried out. If you have any steel stacks in your plant, inspect them now.

Chicago, Ill. C. J. CROWLEY.

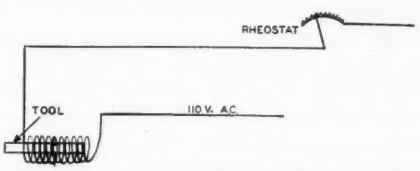
Questions and Answers

Tool Demagnetizing Device

WE HAVE SOME milling tools which have become magnetized and hold a lot of chips while cutting. This keeps the tool cluttered up and makes it difficult to see the lines on the stock, to which it is desired to work. Can you suggest some simple way to demagnetize these tools?

C. W. F.

A. To demagnetize a piece of steel, it is usually necessary only to place the object in an alternating field of some sort and then diminish the field by gradually drawing the magnetized object out of the field.



SIMPLE SOLENOID IN ALTERNATING-CURRENT LINE OFFERS READY MEANS FOR DEMAGNETIZING TOOLS

In the diagram, we have shown how this may be done. The tool is first placed within the core opening of the solenoid which is excited by an alternating current. By keeping the current at full strength for a few moments, then gradually drawing the tool out of the solenoid, it will be found that most of the magnetism will have disappeared.

Such a solenoid can be made up easily by winding several hundred turns of small magnet wire around a bakelite tube and connecting it in series with a small rheostat on a 110-v. alternating current line as shown.

Safe Working Pressure of Boiler

I WOULD APPRECIATE it if you would give me, in plain arithmetic, the safe working pressure of a horizontal return tubular boiler 18 ft. long, 72 in. in diameter with ⅜-in. shell, double riveted along the longitudinal seams.

J. N.

A. The bursting pressure of a boiler may be found by the formula $P = 2\ t\ s \div D$

where P = bursting pressure in pounds per square inch
t = thickness of shell in inches
S = tensile strength in pounds per square inch
D = diameter of shell in inches.

To find the safe working pressure, we must consider two other factors;

e = joint efficiency, and
f = factor of safety

Now, to put this in simple arithmetical form, all we have to do is to substitute figures for the letters, which merely represent values in general. We shall then have:

S = 58,000 Assumed as usual practice
T = ⅜ in. or 0.375
e = 82 per cent or 0.82 for the joint mentioned
f = 5 for given conditions of operation
D = 72 in.

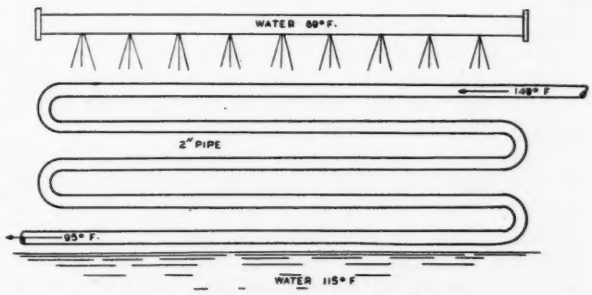
Safe working pressure = $Pw = 2\ S\ t\ e \div f\ D$
$= 2 \times 58{,}000 \times 0.375 \times 0.82 \div (5 \times 72) = 99$ lb.

The safe working pressure may be set therefore at 100 lb.

Heat Transmission of Sprayed Pipe Coils

WILL YOU KINDLY give me information regarding cooling pipe surfaces? I desire to know the rate of heat transfer expressed in B.t.u. per sq. ft. per hour through ordinary 2-in. steel pipe when sprayed upon by cooling water as shown in the illustration. The medium to be cooled enters the 2-in. pipe at 149 deg. F. and is discharged at 95 deg. F.

Water, amounting to 40,000 gal. per hr., is sprayed over the pipe coils at 69 deg. F. and is thus heated to



DIAGRAMMATIC REPRESENTATION OF HEAT TRANSMISSION PROBLEM OF PIPE COILS

115 deg. F. The amount of 2-in. pipe cooled is 30,080 sq. ft.

H. E. B.

A. Since the number of gallons of water heated per hour is 40,000 and one gallon weighs 8.35 lb., the number of pounds of water heated will be $40{,}000 \times 8.35 = 334{,}000$.

Since the rise in temperature of the water is $115 - 69 = 46$ deg. and the number of square feet of piping cooled is 30,080, the amount of heat exchanged will be $334{,}000 \times 46 \div 30{,}080 = 510.76$ B.t.u. per hr. per sq. ft. of piping.

PACKING RINGS for pumps should not be cut too close, because they are liable to swell and seriously interfere with the operation of the pump.

Editorial Comment

Why Not the Whole Story?

Every day we read sensational, or at least bordering on the sensational, stories in trade papers telling how much has been saved by the installation of this or that piece of equipment. "New Plant Pays for Itself in Three Years," "Conveyors Save Firm from Bankruptcy," "Elevators Did It," "Fifty Per Cent Return on Investment," "Plant Doubles Capacity."

True, each of these stories preaches the sermon of progressiveness or modernization so necessary for the continual existence of the present day industry. They touch the imagination of the executive and thus indirectly lead to investigation of conditions in other plants, investigations which may mean changes or may simply show that present conditions cannot be materially improved.

Few of these sensational stories have the information which is of real advantage to the engineer. He knows without being told that it is possible to take practically any plant or department six or eight years old and make changes that will make a good showing with figures properly presented. Information that he is interested in and wants is lacking. The important point for the responsible engineer is not how much was saved but would not some other equipment or combination of equipment have solved the problem to better advantage?

It takes no wizard to pick out modern equipment for an old plant and show a substantial saving. Furthermore, it is a poor engineer who, after installing such equipment, cannot produce operating and cost data to justify the investment. It takes a good engineer, however, to pick best the combination of equipment out of perhaps fifteen or twenty possibilities.

Some of these are of course eliminated automatically by local conditions and limitations, perhaps structural details of the building or limited space, perhaps the presence of dust or acid fumes, perhaps the cost of fuel or power. Chances are, however, that out of the group there will be several possibilities that could be used to advantage.

The important point is, therefore, not how much was saved but how much more was saved than could have been saved by other solutions considered. Why was this particular equipment selected? Judging by average conditions encountered, it was selected by a combination of intuition and good salesmanship.

All of which brings us to a consideration of "salesman engineering" about which so much is thought, less is said and very little written. Undoubtedly it does add a somewhat unevenly distributed burden on the purchaser for no one can think that this engineering service is actually "free" as so often stated. Manufacturers are in business to make money and this "free service" gets paid for eventually.

It does, however, serve a useful purpose to both customer and manufacturer. It gives the former the benefit of a staff of specialists and it allows the latter to present his own equipment to the best advantage. No doubt coffee could be sold on the strength of its color, shape and size of the bean and general appearance, yet a small cup of well made coffee as a sample will do much to impress the flavor upon the customer's mind while a demonstration showing how easy it is to make an impressive demonstration for those who have the responsibility of cooking.

Engineering service gives the equipment manufacturer a background against which to present his equipment to best advantage and is as much a legitimate sales expense as it is free engineering service for the customer. Any salesman can present his case to better advantage in selling a piece of equipment as part of a complete system when its relation to other pieces of equipment is apparent than he can if selling it as a separate and distinct item.

It is easy to present general figures to show the value and savings of feedwater heaters but it is more difficult to sell a heater on these figures than it is if these same figures apply to a specific case and the engineer is shown just where and how the heater fits into his plant, with a revised piping layout, heater supports and other necessary details made clear.

The trouble lies not with the manufacturer but with the engineer who is not capable of analyzing the proposals and arrangements from various manufacturers. Anyone of them is probably a satisfactory arrangement and can be made to show a saving, yet one may show twice the savings of the other. There is a quite natural tendency to select one proposal in its entirety, because it has been effectively presented and meets the conditions.

If, after the installation is selected, the engineer is not in a position to explain his choice of equipment and compare different possibilities as well as tell how much the preferred arrangement is going to save, he has not completed his obligations as a good engineer. Unfortunately this happens only too often and although it is possible to get plenty of figures in support of the change made, questions regarding other arrangements or the reason for doing this or that are met with complete silence or some trivial excuse.

For, after all is said and done, there are many engineers who are not capable of analyzing their own conditions or visualizing the effect of changes. A man who always travels from Chicago to Atlanta via New York could save considerable by going via Washington but he could save still more by going via Concinnati or Louisville. The choice between the last two would be close, probably depending upon comparatively unimportant factors such as starting time or preference for dining car service on one of the roads.

Problems arising in the selection of proper equipment are just as clearly defined although not often as easily solved. Mere statements that certain savings have been made with certain equipment are of no practical value unless supported by comparative data showing what could have been saved by other arrangements, a statement of local conditions and reasons for such

selection. Efficiency is much more important when power is 4 cents per kw-hr. and coal $6.00 per t. than when power is 1 cent per kw-hr. and coal $2.50 per t. Likewise, reliability is more important in some industries than in others.

The capable engineer has all these factors evaluated with definite reasons and data to support his selection; the majority, not quite so capable, content themselves with "we saved $10,000," hoping that the excitement aroused by the stated amount will forestall embarrassing question.

Off Duty

Out in California, they are running efficiency tests on cows! As members of the engineering profession we, naturally, are quite familiar with the running of tests; the practice, in fact, is one of the stabilizing factors in the profession since tests serve to acquaint us with our shortcomings in mathematics and teach us, often to our sorrow, the vast difference between theory and practice. So we run tests on everything in sight; on boilers, on stokers, furnaces, pumps, turbines, generators—why, we even run tests on human beings, measuring their mental and physical reactions by means of jig saw puzzles, funny diagrams and trick words. But never before have we heard of anybody running a test on a cow!

Whether or not we have ever heard of it makes no difference, for in California it is being done. These are the facts. The unsuspecting cow is carefully coaxed into a trick stall and securely locked up in an airtight respiration chamber. Once hermetically sealed in this chamber, the poor beast is at the mercy of the scientists but we understand they treat her well. She is fed, watered, milked and cleaned under laboratory conditions. Her feed is weighed, the water she drinks is analyzed and the air supply is cooled and humidified. Attendants enter the chamber only through air locks to prevent air leakage. The breathing of the animal is measured by an elaborate "mechanical-lung" device called on aspirator, and a classifier in the basement under the respiration chamber separates the waste products. About the only thing that is not analyzed is the cow's moo, although judging from certain radio loud speakers we have heard, we have a sneaking suspicion that the moo is sold as a by-product to the radio industry. In this way, the input-output efficiency of the cow is determined and if she tests low she goes to the foot of the class. It's a hectic world when even a poor cow has to maintain a high CO_2 output to retain her standing in the community.

Things are happening so rapidly, however, that even this news of cow efficiency fails to disturb us; in fact, we refuse to be disturbed or astonished about anything these days. For what is there left to be astonished about after Dr. Bridgman, for instance, comes out with the paradoxical announcement of hot ice—ice at a temperature of 180 deg. F.? Put a block of that into your furnace and you could heat your house with it. No, we are not crazy with the heat although it has been hot here, lately. Nor is Dr. Bridgman's word to be doubted, for he is a thoroughly respected professor at Harvard University. It seems, however, that he has been playing around with high pressures, and when we speak of high pressures here, we don't mean any of the 1800 or 3200 lb. pressures the power plant engineers regard as achievements—we *mean* high pressures. For compared to Dr. Bridgman's 580,000 lb. per sq. in. our 1800 lb. boiler pressure is as a baby's plaything.

Dr. Bridgman finds that funny things happen at such pressures. The characteristics of ordinary substances are altered entirely. The electrical resistance of certain substances decrease enormously, 73 per cent in the case of potassium. Other metals increase their resistance. Under a pressure of 176,000 lb. the freezing point of mercury is brought up to room temperature. And, ice, at a pressure of 290,000 lb. per sq. in. is found stable at 180 deg.!

Speaking of temperatures, however, really, we should be startled at the announcement of the Westinghouse Co. of a temperature of 900,000 deg. F. recently developed in their laboratories. No, the printer did *not* slip in a couple of extra zeros; we intended to say 900,000 deg. Some temperature, eh wot? Guess, even Professor Bridgman's hot ice would melt at that temperature.

This hottest spot in the universe which perhaps it isn't, was attained by Ragner Tanberg while investigating the characteristics of the electric arc in a vacuum. He found that in a nearly perfect vacuum, the arc creates a spot of heat of almost a million degrees, some 90 times as hot as the surface of the sun!

Obviously, no thermometer is capable of measuring so high a temperature directly so it is calculated by measuring the velocity of the molecules of the electrode metal as it is boiled away by the intense heat. Simple, isn't it? How does he measure the velocity of these molecules? Well, you see, he—it's—oh, gosh, ask us something easy.

Anyway, our space is almost used up and we still want to say something about the musical thunder the General Electric engineers have been making. Those boys—the General Electric and Westinghouse research troupe—ought to put on a show some day; they are full of all sorts of tricks. Well, anyway, it seems, the other day several G.E. radio engineers were trying to broadcast on very short wave lengths, and while they have had no trouble in broadcasting power as high as 200 kw. using long waves, with short waves they found it difficult. Every time the power was raised to about 35 kw. they found coronas and arcs flashing from their antennas. Wavering like ghostly spectres, these arcs would start three or four feet from the aerial and then shoot upward four feet into the air.

Since the power supplying the arc was modulated with music, the arc alternately collapsed and built up in size corresponding to the modulation and this action set up in the air vibrations similar to thunder but instead of the roar and roll of thunder it was a musical sound. Men working 400 ft. away thought they were listening to a giant loud speaker. These difficulties with arcs were overcome later by the use of larger conductors.

So it goes, one announcement more startling than the one before. We have yet to learn of a musical earthquake or a singing waterspout but we have hopes. These scientific fellows can do anything, in fact, we understand now that some of them at the Western Electric Co. are attempting the impossible, i.e., the design of a dial telephone so simple that even a U. S. Senator will be able to operate it.

Power Plant Engineering Developments and News

Series "C" Three-Drum Boiler

OF INTEREST to the small and medium sized steam user is the new "C" series of 3-drum boilers recently developed by the Erie City Iron Works of Erie, Pa. It is available in sizes from 80 hp. up for steam working pressures up to 350 lb.

The design is an adaptation of the three-drum boiler introduced several years ago by this company. It embodies most of the features of this early product, refined in many details of manufacture to provide an economical unit where space is an important consideration.

The quality of producing slightly superheated steam, a feature of their early three-drum boiler, is retained, it is stated, in this low headroom boiler by the use of a horizontal steam header or manifold which, as shown in the accompanying illustration, is connected to the rear steam drum by a number of superheating tubes. Slightly superheated steam is discharged into the main steam line horizontally from the end of this header, an arrangement that reduces the headroom considerably over that required for the conventional top steam outlet.

Another interesting innovation is the elimination of the customary rear brick wall and the substitution of well-insulated removable plates to give easy and quick access to the entire rear of the boiler.

Arrangement of baffles is designed to deflect the hot gases over every inch of heating surface in the boiler and to lower their temperature gradually until in the last pass an insulated steel plate rear wall is entirely adequate and a great economy, it is claimed.

To reduce further the cost of installing one of these boilers, many of the smaller sizes are designed to be shipped as a complete unit. The view above, eliminating the four short detachable legs, shows how this unit may be shipped. Series "C" is designed to be adaptable to all firing methods.

THREE-DRUM BOILER FOR RESTRICTED SPACE

New Smaller and More Effective Lightning Arrester

RECENTLY a new material with remarkable electrical properties has been developed by engineers of the Westinghouse Electric and Manufacturing Co. It is both an insulator and a conductor; the particular state it happens to find itself in depends on the voltage stress to which it is subjected and the transition from one to another takes place more quickly than can be measured with instruments that are capable of detecting time intervals of less than one-tenth of a millionth of a second. The ordinary materials used in the electrical arts are either insulators or they are conductors but

NEW 73-KV. WESTINGHOUSE ARRESTER COMPARED WITH THE OLD ON THE RIGHT. INSERT SHOWS RESPECTIVE ELEMENTS OF THE TWO ARRESTERS

this extraordinary one, when it is placed in an electrical circuit and voltage is applied to it, will act as an insulator; in other words, it will not pass any current while the applied voltage is below a certain critical value but when the applied voltage exceeds this critical value, the material quickly changes into a conductor and permits current to flow freely in any quantity necessary to prevent the voltage from rising to higher values. In other words, this material definitely limits the voltage that can exist through it. In this way, it acts electrically exactly like the safety valve on a steam boiler acts hydraulically. In fact, the material is spoken of as an electrical valve. These properties make it particularly suited for use in lightning arresters, whose function it is to hold down the voltages that may occur on transmission lines from lightning and it is so used in the new autovalve lightning arrester.

The remarkable electrical properties of this material are brought about by the fact that it is permeated with very fine pores. There are millions of them in parallel and through them electrical discharges take place when the applied voltage reaches the critical value.

The material is made by methods similar to those used in the manufacture of porcelain and the proper degree of porosity is secured by the proper selection, molding, and firing of the ingredients.

Taking the Welding Equipment to the Work

CLARK TRUCWELDER is a recently-developed complete, mobile, self-contained, gas-powered, electric arc welding unit, designed to be capable of 24-hr. continuous operation and to be especially useful in places and on work where there is no convenient source of electric power. The Trucwelder is made to take the welding equipment to the work.

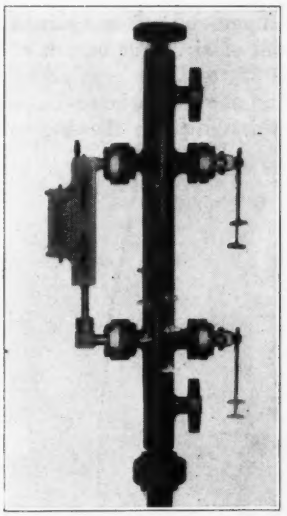
The unit is equipped with self-starter and headlights, carries all necessary welding accessories (General Electric standard), has ample room for acetylene tanks (for cutting), seating room for crew and ample power for towing trailers.

Arc welding current, ranging from 60 to 250 amp. at 25 v., is developed by a self-excited G. E. arc welding generator with control, driven by a special heavy duty, four-cylinder gas engine developing 20 hp. at 1480 r.p.m. Currents between 25 and 60 amp. may also be obtained by inserting in the circuit a current-reducing resistor provided for the purpose. The current available is stated to be ample for use with all commercial sizes of metallic electrodes from $\frac{1}{16}$ in. to $\frac{3}{16}$ in., also for light carbon welding and cutting. The Trucwelder is made by the Clark Tractor Co., Battle Creek, Mich.

MOBILE ARC-WELDING EQUIPMENT

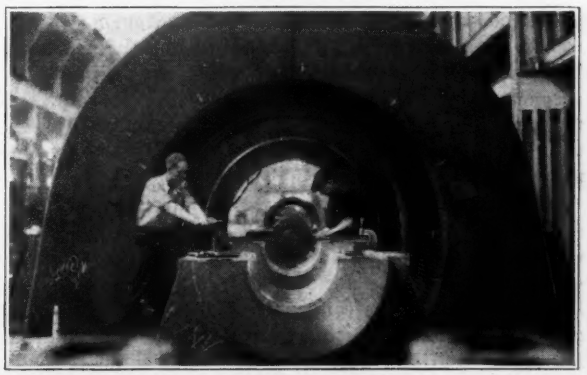
Water Column for 1800 Lb. Pressure

IN THE ACCOMPANYING PHOTOGRAPH is shown a water column designed for 1800 lb. working steam pressure, one of four just completed by the Reliance Gauge Column Co., Cleveland, Ohio, and shipped to the Philip Carey Co., Cincinnati, Ohio. These are to be used on the boiler installation now being made for the latter by the Combustion Engineering Corp. These boilers are to operate at 1800 lb. steam pressure. The water gages and gage cocks on these columns are also of Reliance design and manufacture. The entire assembly was tested at 3000 lb. hydraulic pressure before shipment from the factory.



DETAILS OF RELIANCE 1800-LB. WATER COLUMN

Where Accuracy Counts

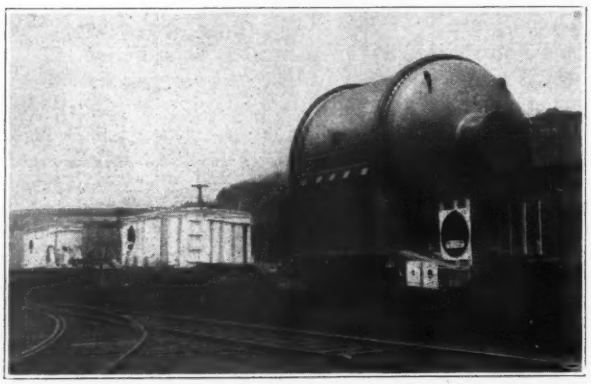


LINING UP the stator on the base of a General Electric 27,500-hp. induction motor. This motor, part of a 20,000-kw. 300-r.p.m. Scherbius control 25 to 60-cycle frequency converter, will be shipped to the Union Electric Light and Power Co., St. Louis, Mo.

Hydrogen Cooled Synchronous Condenser for California

IN THE ACCOMPANYING photograph is shown a view of a hydrogen cooled synchronous condenser which was shipped recently by the Westinghouse Electric & Manufacturing Co. at East Pittsburgh to the Southern California Edison Co. for automatic regulation of the voltage on their transmission circuits. This machine is rated 15,000 kv-a., 11,500 v., 3 phase, 50 cycle, 750 r.p.m., and will be filled with hydrogen gas for cooling instead of air.

Many advantages have been gained by the use of hydrogen instead of air. The output of the machine is increased about 25 to 30 per cent above that for operation in air. The power consumed in losses is considerably reduced, this reduction showing up to very great



HYDROGEN FILLED SYNCHRONOUS CONDENSER READY FOR SHIPMENT TO CALIFORNIA WHERE IT WILL BE INSTALLED ON THE LINES OF THE SOUTHERN CALIFORNIA EDISON CO.

advantage at the fractional loads. The damage to insulation arising from static discharge is practically eliminated. Fire hazards are reduced to a minimum since hydrogen does not support combustion. The machine will always be clean inasmuch as it must necessarily have a closed system of ventilation which eliminates dirt.

The condenser will be operated out-of-doors and requires no structure to house it. The hydrogen is water cooled, the coolers being located within the machine. The collector rings and brushes are in a small chamber at one end of the machine and these may be inspected through small glass windows or when the machine is shut down, this end may be removed without affecting the hydrogen within the condenser.

In filling the condenser with hydrogen, an inert scavenger gas is used to expel all of the air. This operation insures against having an explosive mixture of gas at any time in the operation of filling with hydrogen. After the condenser is filled with hydrogen, an explosion is impossible even though there were some source of ignition. Nevertheless, the machine is made explosion proof. The pressure inside is maintained above atmospheric so that even the negligible leakage of hydrogen will be outward. The gas is supplied from steel tanks which are provided with suitable valves to reduce the pressure for admission into the machine. Instruments mounted on panel boards inform the operator of the pressure within, the percentage of hydrogen, the temperature in various parts, etc. Numerous alarm signals are provided whereby the attendant is notified in case there is a departure from normal conditions in any respect.

University Builds New Plant

ON THE CAMPUS at Berkeley, Cal., the University of California is building a new heating plant. With the exception of some minor piping work in the tunnel, all contracts have been let and foundations, steel work and distributing tunnel were complete by the early part of June.

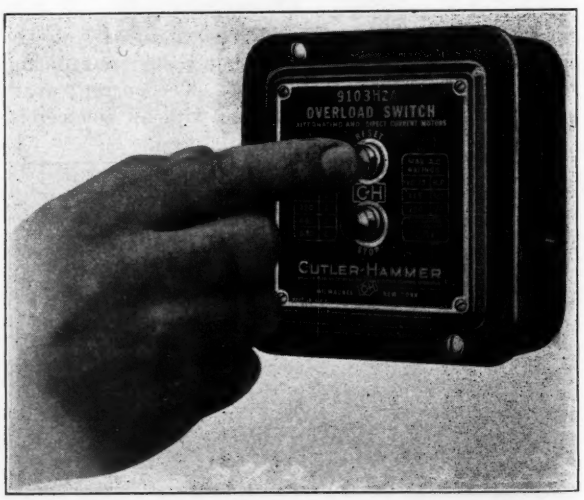
At present the peak load, beginning about 5 a. m. on a chilly morning, runs about 1800 b.hp. On many days this drops to 600 b.hp. or less by 10 a. m. and during the night load ranges around 200 b.hp. Because of the low load factor, the generation of steam for heating only and the cheap fuels available, the plant is exceedingly simple. Lack of synchronism between the heating load and the electric power load, together with the low price of hydroelectric power from public utility companies, made generation of electric power undesirable.

In normal operation, the fuel used will be excess natural gas from the recently completed gas transmission system from the Kettleman Hills district into the San Francisco Bay territory. Fuel oil will be installed for standby and reserve.

Equipment being installed consists of four Babcock and Wilcox boilers, two 6080-sq. ft. units removed from the old power plant and two new 6800-sq. ft. units. All four boilers are designed for maximum rating of 200 per cent. The operating steam pressure will be 125 lb. ga.

Starting Switch for Small A. C. or D. C. Motors

FOR CONVENIENT starting and stopping of small d.c. and polyphase motors, Cutler-Hammer, Inc., 191 12th St., Milwaukee, Wis., offers a new two-pole, push-button operated starting switch with thermal overload relays. This new starting switch can be used



STARTING SWITCH FOR SMALL MOTORS

with d.c. motors up to ½ hp., 115 v. and ¼ hp., 230 v. or with a.c. motors—single, two or three-phase up to 2 hp., 110 to 550 v. Small in size—the enclosing case is a standard wiring box—the switch can be mounted right on the machine, at the operator's finger tips. For machinery builders, an open type switch for building directly into the machine is offered.

Double-break, silver contacts and a quick-break contact mechanism are used to assure long life and continuous current carrying capacity. The termal overload relays are designed to allow working the motor to the limit—yet to disconnect it as soon as an overload becomes dangerous to the motor. When tripped by an overload, simply pushing the "reset" button resets the relay and starts the motor. The enclosed switch has conduit knockout holes in the top and bottom for easy wiring. Arrangements are provided for sealing the cover if desired.

News Notes

According to a recent announcement, the New York Steam Corp., New York, has recently awarded a contract to the Fuller Lehigh Co. for coal pulverizers and auxiliaries. The new equipment will be installed at the Kips Bay Station, New York City, to operate in connection with a bin storage pulverized-coal system serving five boiler units. Two type B Pulverizers, a new development of the Fuller Lehigh Co., will be supplied. They will have sufficient capacity for grinding 25 to 40 t. of coal per hour respectively.

J. B. McMahon, the Tulsa branch manager of The Foxboro Co., will hereafter make his headquarters at the home office at Foxboro, Mass. He is to take charge of all field engineering service and will be responsible for all direct sales effort. G. B. Lane, former manager of the Detroit office, has succeeded Mr. McMahon as branch manager at Tulsa.

McClave-Brooks Co. announces that the Eagle Oil & Supply Co., 74 West 2nd St., South Boston, Mass., is now representing it exclusively in the states of Maine, New Hampshire, Vermont, Massachusetts and Rhode Island. Geo. H. Vincent, 818 Chapel St., New Haven, Conn., is representing the company exclusively in the state of Connecticut.

International Filter Co. and associated companies, International Water Softener Co. and General Zeolite Co., announce the removal of their general offices and engineering departments from Plant No. 1 at 333 West 25th Place, Chicago to larger quarters covering the 13th and part of the 14th floor of the Buckingham Building, 59 E. Van Buren St., Chicago, Ill.

Simplex Valve and Meter Co. announces the appointment of Goldsborough & Vansant, Inc., Farmers Bank Building, Pittsburgh, Pennsylvania as district representative for the Pittsburgh Territory, effective on and after July 1, 1930.

Benjamin C. Smith, president of Standard Motor Construction Co. of Jersey City, N. J., announces the appointment of L. S. Devos as general sales manager to take effect at once.

Superheater Co., New York City, announces that its Chicago office was moved on July 1, 1930, from Room 801 to Room 1325, 122 South Michigan Blvd., Peoples Gas Bldg., Chicago, Ill.

Frank J. Oakes, general superintendent of the Dodge Works of Link-Belt Company, Indianapolis, Ind., died suddenly of apoplexy at his home, on July 19, at the age of 54. He was born at Decatur, Ill. He entered the service of the Link-Belt Machinery Co., Chicago, in 1894, as repairman and general machinist. In June, 1899, he obtained a leave of absence for one year, to serve as repair man for the Mexican Central Railway, in Chihuahua. On his return to Link-Belt Co., Chicago, in 1900, he served as repairman and assistant foreman in the sheet and structural iron department. In 1907 he was placed in charge of the tool room, and in March, 1912, he was appointed Foreman of the Machine Shop and Tool Room. In August, 1913, he was transferred to Philadelphia, from which he was transferred two years later, and made general superintendent of the Dodge Works, Indianapolis, which position he held at the time of his death. Mr. Oakes was a member of the Society of Automotive Engineers, the American Society of Steel Treaters, the American Gear Manufacturers Association and several other engineering societies.

J. A. Palmer, president of the Burt Manufacturing Co., Akron, O., suffered shoulder and cranial injuries when struck by an automobile on July 22 at Burlingame, Calif., where he was spending a vacation.

Palmer, with his wife, is vacationing with relatives here.

Mercon Regulator Co., Chicago, Ill., announces that E. F. Eckel, recently general manager of the Henszey De-Concentrator Co., has joined it as salesmanager. John M. Coffeen, recently western manager for Neilan, Schumacker and Co., has become chief engineer.

Announcement is made that the National Power Show will be held in New York from Dec. 2 to 7, 1930.

General Refractories Co., Philadelphia, Pa., announces the opening of a new district sales office in the Empire Bldg., Birmingham, Ala., in charge of Walter S. Stapler.

New Distributors who will handle the products manufactured by Chain Belt Co. of Milwaukee, Wis.: The Equipment Corp. of Arizona at Phoenix, F. C. Crane Co. of Dallas, Texas, Joe C. Tucker of Morganfield, Ky., Track-Type Tractor and Equipment Co. of Amarillo, Texas, and Concrete Products Co. of Oakland, Cal. In addition, the company has appointed the E. C. Atkins and Co., Inc., of Memphis, Tenn., as representative. The Atlanta office of the company has recently been moved to 407 and 408 Bona Allen Building, Atlanta, Ga.

Poole Engineering and Machine Co. has appointed Neil Otey, formerly of the main office at Baltimore, Md., as district manager of its Pittsburgh office, with headquarters at 245 Union Trust Building.

United States Civil Service Commission announces the following open competitive examinations: Principal Civil Engineer, Senior Civil Engineer, Senior Electrical Engineer, Senior Mechanical Engineer, Civil Engineer, Mechanical Engineer.

Applications for the above-named positions must be on file with the Civil Service Commission at Washington, D. C., not later than September 10, 1930.

These examinations are to fill vacancies in the Bureau of Reclamation, Department of the Interior, and vacancies occurring in positions requiring similar qualifications, for duty in Washington, D. C., or in the field. Positions in connection with the Boulder Dam project will be filled from these examinations; also in connection with designs and specifications for the proposed All-American Canal of the Reclamation Service. Entrance salaries range from $3800 to $6400 a year. Higher-salaried positions are filled through promotion. Competitors will not be required to report for examination at any place, but will be rated on their education, experience, and fitness.

Full information may be obtained from the United States Civil Service Commission, Washington, D. C., or from the Secretary of the United States Civil Service Board of Examiners at the post office or customhouse in any city.

McClave-Brooks Co., Scranton, Pa., announces that S. C. Orell, formerly district sales manager for the Murray Iron Works, Burlington, Ia., assumed his duties as manager of its Chicago district territory on August 1, 1930.

Effective August 1, 1930, the Reynolite Division of the Reynolds Spring Co., Jackson, Mich., became the wholly owned subsidiary of Cutler-Hammer, Inc., Milwaukee, Wis.

Books and Catalogs

New Building Estimators' Handbook. By William Arthur. Published by the Scientific Book Corp., 15 E. 26th St., New York, N. Y.; fifteenth edition, 992 pages; size, 5 by 7 in.; price, $6.00.

Because of the nature of the material, it is impossible to do much beyond outlining in a general way the table of contents of this very valuable book, whose value to the power plant designer and plant engineer is not indicated in the title. It gives a great deal of information and data not readily accessible but yet of extreme importance to power plant engineers. In the introduction a brief review of the methods of estimating is given and in the following 30 chapters several are of unusual interest to our field.

Among these are Measurements of Building Work, Excavation and Filling, Piling and Underpinning, Concrete Work, Reinforced Concrete, Brickwork, Structural Iron and Steel, Millwork, Glass, Roofing, Painting, Heating, Electric and Conduit Work, Tiling and Asbestos Materials. In addition, there is a valuable chapter devoted to Weights and Measures, Useful Memorandums and Tables, Costs and Quantities.

HEAT TRANSFER IN AMMONIA CONDENSERS, Part III. By Alonzo P. Kratz, Horace J. Macintire and Richard E. Gould. Published as Bulletin No. 209, of the Engineering Experiment Station, University of Illinois, Urbana, Ill.; price, 35 cents.

This bulletin contains a study of the performance of the horizontal shell-and-tube condenser. The object of the investigation was to determine the coefficient of heat transfer, the effect of ammonia pressure on the coefficient of heat transfer, the rate of scale formation or fouling of tubes, the performance characteristics of the condenser, and the various rates of flow and water temperature. Previous publications, bulletins Nos. 171 and 186, Parts I and II, dealt with the atmospheric-bleeder and the vertical shell-and-tube condenser.

TENSION TESTS OF RIVETS. By Wilbur M. Wilson and William A. Oliver; published as Bulletin No. 210 of the Engineering Experiment Station, University of Illinois, Urbana, Ill.; 36 pages; price, 35 cents.

Results of a series of tests to determine the strength of rivets in tension. There were 27 groups of three rivets each in the first series and 34 groups of four rivets each in the second. Some rivets were driven with an air hammer, others with a press riveter. The influence of a number of variables was determined, as follows: type of head, length of grip, temperature of rivet when driven and time required to drive the rivet.

PATENTS, TRADE-MARKS AND COPYRIGHTS, by Oscar A. Geier, is the title of a 6 by 9 in., 120-page cloth bound book published by Richards & Geier, Patent and Trade-mark Attorneys, 274 Madison Ave., New York, N. Y. This is the fifth edition of this book prepared as a general review of the patent law and practice in this and foreign countries.

A STUDY OF SLIP LINES, Strain Lines and Cracks in Metals Under Repeated Stress. By Herbert F. Moore and Tibor Ver. Published as Bulletin No. 208, by the Engineering Experiment Station, University of Illinois, Urbana, Ill.; 60 pages; price, 35 cents.

A description of the materials, test specimens and apparatus used, with a discussion of the results of several metals subjected to repeated-stress test. The metals studied were Armco iron, plain carbon steel, chrome nickel steel, stainless iron, brass, Monel metal and Duralumin.

HEAT POWER. By Earle B. Norris and Eric Therkelsen. Published by McGraw-Hill Book Co., 370 Seventh Ave., New York, N. Y.; size, 6 by 9 in.; 366 pages; price, $3.50.

An elementary book on heat power engineering in which the traditional arrangements have been changed and the steam power machinery presented after the more familiar internal combustion engine has been covered. It is the authors' belief that, as every American youth can operate an automobile and knows something of the principles of operation of its engine, this knowledge offers a logical starting point for the fundamentals of heat engines and that in this way the approach to thermodynamics will be facilitated.

EVAPORATING, CONDENSING AND COOLING APPARATUS. By E. Hausbrand, translated by A. C. Wright and revised and enlarged by Basil Heastie; published by D. Van Nostrand Co., 250 Fourth Ave., New York, N. Y.; Fourth English Edition; size, 6 by 9 in.; 456 pages; price, $8.00.

A very complete work dealing with heat transfer in evaporating, condensing and cooling apparatus of all types. The first German edition appeared in 1899 and subsequent German and English editions over a period of years testify to the completeness and popularity of the book. The present edition has been brought up to date and incorporates the recent researches in the National Physical Laboratory. In the Appendix is a set of metric-British conversion tables. Of the 27 chapters, the Flow of Liquids, Vapors and Gases through Pipes, Loss of Heat to the Surrounding Air, Condensers and Condenser Air Pumps are of greatest interest to the power plant man. The other chapters deal with practically every form of heat transfer equipment used in process work and the large amount of experimental data included makes the volume very valuable to industrial plant engineers.

PIPE HANDBOOK, by J. H. Walker and Sabin Crocker, assisted by several other contributors; 764 pages, 225 illustrations, 206 tables; flexible cloth binding, 4½ by 7 in.; published by McGraw-Hill Book Co., New York; price, $5.

The purpose of this book is to provide authoritative and accessible data for the engineer interested in the design, construction and operation of piping systems in power distribution and industrial plants.

Specialized subjects such as heat insulation, water supply piping, oil piping and gas piping are presented by special contributors who are authorities on their subjects. Properties and flow of fluids, metallurgy of piping materials, apparatus and piping for different purposes, are discussed and many helpful formulas, tables and charts are included.

NOTES ON HYDROGEN ION MEASUREMENTS has just been issued as Notebook 3 by Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. This is not intended to be catalog but to be an engineering treatise of use to those interested in measuring acidity or alkalinity of water solutions by electrical methods. The following topics are discussed: Meaning of Hydrogen Ion Concentration and pH value; Electrometric Hydrogen Ion Measurements; Hydrogen Electrode; Calomel Electrode; Potentiometer Principle; Assembly for Hydrogen Ion Measurements; Quinhydrone Electrode; Quinhydrone pH Electrode. The major portion of the text not only describes the apparatus used for measuring pH but also tells how it is used and what its limitations are. Fundamental principles are briefly and clearly explained.

SIMPLIFIED LIST of Dart Union Fittings, No. 4-30, illustrating each fitting and giving tables of sizes and prices, has just been issued by E. M. Dart Mfg. Co., Providence, R. I.

PALMER-BEE Over-head and other Conveyors are described and illustrated in Catalog No. 52, a pleasing 80-page publication by Palmer-Bee Co., Detroit, Mich. Details of trolleys, chains, drives and supports are shown, also layout drawings and views of typical installations. Conveyors for ovens, foundries, coal and ash, and all industrial operations are shown and described.

ROSS FEEDER for ore, coal, coke, stone and other granular material is described in detail by Ross Screen & Feeder Co., 247 Park Ave., New York, in its recent catalog No. 2/1930. This discusses the application of a chain curtain to control flow of material from hoppers or open dump chutes. The feeder-screen and curtain screen are also described.

TOGGLEBUG DRILL, a portable drill designed for drilling and reaming structural steel work in the field, is described in a recent bulletin by Guibert Steel Co., P. O. Box 1037, Pittsburgh, Pa.

LINK-BELT CLEAN WATER INTAKE SCREENS are described in Book No. 1252 recently issued by Link-Belt Co., Chicago, Ill. This 24-page well-illustrated book describes installations of the screens in power plants, pumping stations and the like and gives details of the screen construction.

A NEW TOOL FOR INDUSTRY, an 8-page illustrated bulletin published by The Spencer Turbine Co., Hartford, Conn., describes and illustrates various applications of the Spencer Central Cleaning System in power plants and all types of industrial plants.

CENTRIFUGAL BLOWERS AND COMPRESSORS are described in two well-illustrated bulletins recently issued by Elliott Co., Jeannette, Pa. Bulletin P-4 describes Type M and S Centrifugal Blowers, multi-stage and single-stage, double-inlet type, particularly suited to gas boosting at modern pressures and for handling air and gases at higher pressures. They are turbine-driven; many installations are described. Bulletin P-5 describes the Elliott Type O Blower, a single-stage, single-inlet overhung impeller type designed popular for all-around service, particularly in blowing water gas generators. These are adapted to either motor or turbine drive.

CATALOG No. 202, on Bulk Material Handling Conveyors, has just been published by the Chain Belt Co. of Milwaukee, Wis. This 72-page book gives complete engineering data and illustrations on bucket elevators of all types, super-capacity elevators, bin gates, track hoppers and feeders, steel apron and pan conveyors, weigh larries and screw conveyors. The line also includes chain and transmission equipment, foundry and sand handling systems and conveying systems for various industries. The construction equipment line includes cement mixers of all sizes, pavers, pumps, central mixing plants, Moto-Mixers, saw rigs, contractors' elevators and plaster and mortar mixers.

METTLER GAS BURNERS, including the latest development of the company, the Mettler full automatic conversion burner, are described in a new catalog which has just been issued by the Lee B. Mettler Co., 406 S. Main St., Los Angeles, Cal. The Mettler entrained combustion principle of burning gas, which has been used in the larger size burners, has been incorporated in the new conversion burner and it is claimed that this makes it possible to use primary air only for combustion.

ON THE OCCASION of the Second Plenary World-Power Conference in Berlin, the "Demag News," published by the Deutsche Maschinenfabrik A.-G., at Duisburg, Germany, published a special issue of 62 pages devoted entirely to equipment, such as coal conveyors, seamless tubes, gas engines, pumps, boilers, cranes and electric furnaces which they manufacture and which are of particular interest to the power industry. This magazine is regularly published in German, English, French, Spanish and Portuguese.

BOOK No. 1191, illustrating and describing the complete line of Caldwell screw conveyor drives, has just been published by H. W. Caldwell & Son Co., 2410 West 18th St., Chicago, Ill. The 32 pages of this book are devoted to illustrations of these drives, typical installations of the equipment, and engineering data to enable one to select, without confusion, the most efficient and economical drive for the individual purpose.

GOULDS PUMPS, INC., Seneca Falls, New York, is now distributing the second of its series of Centrifugal Pump Selection Chart Bulletins, No. 201. This second book covers multi-stage pumps for capacities up to 2000 g.p.m. and heads up to 2400 ft. As with the first book, a comprehensive group of charts is provided to enable the prospective pump user quickly and easily to determine just what pump is best suited to his individual requirements. Complete description, including cross sections, bearing details and dimensions for each pump follow. For Bulletin 200, the first series of the bulletins, revisions for pages 3, 3a, 3b and 5 are also issued to be inserted in the bulletin.

LEAFLET 20459, just published by the Westinghouse Electric and Manufacturing Co., presents a description of the construction, operation and application of directional and bus ground relays. These include the Type CWC Directional Residual Relay, the Type CRC Directional Overcurrent Relay and the Type BG Bus Ground Relay. Types CWC and CRC are used for ground protection on grounded neutral systems; the Type BG is designed to slip over a grounding bus and to trip a circuit-breaker, operate an alarm, or perform both operations, when a heavy ground current flows.

INSPECTION, RETEST AND USE OF ELECTRICIANS' RUBBER GLOVES, N.E.L.A. publication No. 055, has recently been issued by the Meter Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York City.

To meet an apparent need for a procedure applying to the retest and inspection of electricians' rubber gloves, a general procedure is presented that may be adopted in whole or in part as best suits the individual company's operating conditions.

Typical electrical and mechanical testing apparatus is shown and explained in detail with the precautions necessary for its installation and operation. The various records to be kept are explained and sample forms shown. The storage, transportation and field use of rubber gloves is outlined, including typical rules governing employe use. To promote safety, ways and means of conveying warnings, safety messages and slogans are suggested.

NEW DEVELOPMENTS IN ELECTRICAL MEASURING DEVICES, N.E.L.A. publication No. 062, has recently been issued by the Meter Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York City.

Manufacturers of electrical measuring devices periodically announce information concerning improvements in their product and the addition of new designs to their listings. New inventions are frequent in measuring devices to meet the exacting demands of the constantly changing methods of distribution as well as for new applications for electrical energy.

This report, in dealing with such announcements, sets forth the manufacturers' claims, illustrates the devices and their uses and briefly outlines their characteristics and general dimensions.

STORES REPORTS, N.E.L.A. publication No. 059 has recently been issued by the Purchasing and Storeroom Committee, Accounting National Section, National Electric Light Association, 420 Lexington Ave., New York City.

The need for comprehensive reports on matters for which the Stores Department is responsible is discussed. Standardization of these reports between companies would greatly facilitate intercompany comparisons.

The various kinds of reports are described and illustrated for the convenience of those who may have occasion to use them, from the local storekeeper to the highest company executives.

Typical samples of report forms are illustrated, although it is expected that each company will adopt forms best suited to its own needs and accounting methods.

Reports concerning the control of stores, computation of turnover, costs of handling materials, and other important statistics are described and illustrated.

A summary of information on stores statistics gathered through questionnaires sent out by the committee concludes the report.

AUTOMATIC ARC WELDING by the Electronic Tornado Process is the title of an attractive 40-page booklet, recently announced by The Lincoln Electric Co., Cleveland, Ohio. This booklet contains information on automatic welding with the carbon arc and describes in detail the advantages of this process. Results of tests of strength and ductility are tabulated and fully described. Other pages show the application of the Electronic Tornado in various industries and record in detail the speed and costs attained.

MATERIAL HANDLING EQUIPMENT, by Edward J. Tournier; 409 pages, 326 illustrations; cloth binding, 6 by 9 in.; published by McGraw-Hill Book Co., 370 Seventh Ave., New York, price, $4.

Complete survey of the use of mechanical handling devices is presented in this ably written volume. It discusses the economy of mechanical handling in general and serves as a guide for the selection of suitable equipment and for most economical methods of purchasing the machinery selected. Application and maintenance of the different types to specific problems is discussed.

This book aims, also, to show how certain formulas may be used to determine, in advance, the possible gains from the installation of material-handling equipment. It should be useful to all who now have material-handling equipment, as well as to all who contemplate purchasing this class of equipment.

DIESEL ENGINE OPERATION, MAINTENANCE AND REPAIR, by Charles H. Bushnell; 285 pages, 192 illustrations, 17 tables; cloth binding, 6 by 9 in.; published by John Wiley & Sons, Inc., 440 Fourth Ave., New York; price, $3.50.

This book is written from the viewpoint of an operating engineer. Such theory as is presented is given a direct application that may be made by any good operating engineer. For example, the author uses the simple method of determining the value of the exponent, n, of the equation for expansion by use of logarithmic paper and for analysis uses a temperature-volume diagram instead of the temperature-entropy diagram.

Different makes of engines are grouped and described with line-drawing illustrations and diagrams which emphasize the essentials and omit irrelevant details.

We regret that mechanical fuel injection is termed in this book, the "Vickers system." If a proper name is to replace the usual terms given to solid injection, it would seem proper to use that of the originator of the method who also first put it into commercial use—Akroyd.

The book is well written. It is full of helpful operation and maintenance suggestions and should be interesting to all who are concerned with Diesel engines and particularly helpful to those who operate them.

ELEMENTS OF STEAM AND GAS POWER ENGINEERING. By Andrey A. Potter and James P. Calderwood, published by McGraw-Hill Book Co. Inc., 370 Seventh Ave., New York, N. Y.; third edition; size, 6 by 8 in., 357 pages; price, $2.75.

A general survey of the principles underlying the construction and operation of steam and gas power equipment. The main portion of the book is divided into three parts dealing with steam power plants, gas power and internal combustion engine plants and the application of steam and gas power to automobiles, trucks and tractors. The arrangement of the book and of each individual chapter is logical; first, dealing with the fundamental principles underlying the particular phase of equipment under consideration; second, structural details; third, auxiliary parts; fourth, operation and management of the equipment considered. Although prepared primarily as a textbook, the treatment is such that it should prove a considerable value to the operating engineer, particularly those engineers interested in a general review of the entire field before getting into details of the individual parts of the plant. A list of problems at the end of each chapter increases the value of the book for this purpose.

WESTINGHOUSE ELECTRIC AND MFG. CO. has published recently its Leaflet 20485 covering the new M line of auxiliary relays for a.c. or d.c. circuits. This line, which consists of the MA, ML, and MX relays, is comprised of reciprocating contactors for automatic and remote control switching. Typical applications are: bell alarm, multiple breaker tripping, lockout, interlocking and master control unit application.

TYPES SC AND SC-1 Current Relays and Type SV Voltage Relay are described in Leaflet 20460, published by the Westinghouse Electric and Manufacturing Co. These relays are particularly applicable where a small, compact, instantaneous relay having a high degree of accuracy is desired to protect circuits or apparatus from over-current or under-voltage. They have two independent circuits: one make and one break, two makes, or two breaks. This leaflet presents application, construction, and operation data, and includes photographs of the equipment, operating characteristic curves, and diagrams showing construction.

DEPARTMENT OF THE INTERIOR, Dominion of Canada, has just issued a report on New Brunswick of 166 pages, with 33 photographs, 10 sketch maps and a general map in color. The potentialities of this maritime province have undoubtedly been overlooked during the period of the agricultural development of Western Canada and the industrial growth of Ontario and Quebec, for it is only recently that its water-powers and forest wealth have been utilized in large-scale pulp and paper enterprise. Progress in this direction has indeed been remarkable. Last year the largest power site in the Maritime was developed at Grand Falls, with an installation of 60,000 hp. and transmission line of 104 mi. to Chaleur bay; 5500 hp. was added to the 9000 hp. already developed on the Nipisiguit; the capacity of the plants at Edmundston and Bathurst were enlarged; while a newsprint mill with an initial daily capacity of 250 t. came into operation in March, 1930; and a bleached sulphite mill at Athol has lately been completed.

A similar awakening is in evidence in regard to the fertile and cheap agricultural lands, minerals and fisheries, and the many recreational attractions of the province, all of which resources and the development opportunities they present are dealt with in this governmental publication, which can be obtained from the Director, Natural Resources Intelligence Service, Department of the Interior, Ottawa.

Power Plant Construction News

Ark., Hampton—The Consumers Utility Co., Little Rock, is said to be planning early rebuilding of portion of electric light and power plant at Hampton, recently destroyed by fire with loss of about $45,000.

Calif., Pasadena—The Municipal Lighting Department has engaged Bennett & Haskell, First Trust Building, Pasadena, architects, to prepare plans for a one-story addition to municipal electric light and power plant on Glenarm Street, to cost about $150,000, exclusive of equipment. Bids will soon be asked. Entire project is reported to cost about $1,000,000.

Colo., Boulder—The Public Service Co. of Colorado, Gas and Electric Building, Denver, has begun an addition to boiler plant at its steam-operated electric generating station at Boulder, to cost about $100,000, with equipment.

Del., Wilmington—The Hercules Powder Co., duPont Building, plans installation of electric power equipment in proposed new experimental works on tract of land near the city, totaling about 300 acres, entire project to cost over $1,000,000. Work will proceed immediately.

Fla., Miami—The Miami Lime & Chemical Co., care of T. H. Newman, 2501 S. W. Sixteenth Terrace, recently organized by Mr. Newman and associates, plans installation of electric power equipment in proposed new local plant for the manufacture of dry ice, entire project reported to cost more than $100,000.

Ill., Wilmington—The Orenda Corporation, Wilmington, with headquarters at West Forty-fourth Street and Oakley Avenue, Chicago, Ill., is said to be planning installation of electric power equipment in connection with proposed rebuilding of paper mill at Wilmington, destroyed by fire July 26, with loss estimated at close to $100,000.

Ky., Lexington—The Lexington Water Co., Lexington, has approved plans for the construction of a series of small power substations on the Richmond Road, for power service for water properties, installation to include steel transmission towers, transformers, switching and metering equipment, etc. Service will be secured from the Lexington Utilities Co.

Md., Baltimore—The United States Industrial Alcohol Co., Fairfield, is said to be planning installation of electric power equipment in connection with proposed rebuilding of portion of plant recently destroyed by fire with loss of about $200,000. Headquarters of the company are at 60 East Forty-second Street, New York.

Mass., Salem—The Eastern Massachusetts Electric Co., Washington Street, is arranging for a stock issue to total about $1,193,000, a portion of the proceeds to be used for expansion and betterments. The company has plans for a new steam-operated electric generating plant on local site, reported to cost close to $15,000,000.

Mich., Ahmeek—The Calumet & Hecla Consolidated Copper Co., Lake Linden, Mich., has authorized the immediate construction of a new power plant for auxiliary service at Ahmeek. The Stone & Webster Engineering Corporation, 38 South Clark Street, Chicago, Ill., is engineer.

Minn., Cloquet—The Minnesota Power & Light Co., Duluth, is said to be planning rebuilding of portion of power plant at Cloquet, recently destroyed by fire with loss reported close to $25,000.

Minn., St. Charles—The City Council is considering an addition to the municipal electric light and power plant, including the installation of a Diesel engine unit, estimated to cost about $45,000. E. A. Dingle is engineer.

Mont., Shelby—The City Council is considering the installation of a municipal electric light and power plant with Diesel engine unit; estimates of cost will soon be made.

N. J., Belleville—The Wallace & Tiernan Co., Inc., 11 Mill Street, will install electric power equipment in proposed addition to chlorine equipment manufacturing plant, entire project to cost over $150,000. A building permit has been issued. Fletcher-Thompson, Inc., 31 Fulton Street, Newark, N. J., is architect and engineer.

N. J., Manville—The Borough Council is said to be planning the installation of pumping equipment, in connection with a proposed municipal waterworks, for which a bond issue of $225,000, has been sold. It is understood that bids for equipment will be received at an early date.

N. J., Secaucus—The Board of Hudson County Freeholders, Court House, Jersey City, has authorized the immediate construction of a one-story and basement power plant at Secaucas, reported to cost close to $100,000, with machinery.

N. Y., Buffalo—The Elk Street Market Corporation, 228-262 Perry Street, plans installation of a cold storage and refrigerating plant in connection with a new public market building, for which plans have been filed, entire project to cost over $500,000.

N. Y., Buffalo—The Ford Motor Co., Dearborn, Mich., plans construction of a boiler plant and installation of electric power equipment in new assembling plant on Hamburg Turnpike, Buffalo, for which a building permit has been issued, entire project to cost over $1,500,000. Albert Kahn, Inc., Marquette Building, Detroit, Mich., is architect.

N. Y., Kirkville—The Central New York Face Brick Co. is said to be planning installation of electric power equipment in connection with projected rebuilding of portion of plant, recently destroyed by fire with loss approximating $100,000.

N. Y., Ticonderoga—The International Paper Co., 100 East Forty-second Street, New York, is reported planning early rebuilding of portion of power plant at mill at Ticonderoga, recently destroyed by fire, with loss of about $25,000.

Ohio, Youngstown—The Youngstown Ice & Fuel Co., 1421 West Federal Street, has filed plans for a two-story ice-manufacturing plant, 150x200 ft., to cost $150,000, with equipment. G. B. Bright, 2615 Twelfth Street, Detroit, Mich., is engineer.

Okla., Oklahoma City—The Oklahoma Gas & Electric Co., Oklahoma City, is said to have plans under way for a two-story steam-operated electric power plant to cost over $200,000. Engineering department of company will be in charge.

Okla., Tulsa—The St. Louis-San Francisco Railway Co., Frisco Building, St. Louis, Mo., has approved plans for a one-story power plant at Tulsa, reported to cost more than $80,000, with equipment. F. G. Jonah, address noted, is chief engineer.

Pa., Pittsburgh—Edward G. Lang, director, Department of Public Works, City-County Building, will receive bids until Aug. 12, for a pumping unit and accessories for the Herron Hill pumping station, as per specifications on file.

Texas, Anna—The Common Council is said to be planning the installation of pumping machinery and auxiliary equipment in connection with extensions and improvements in municipal waterworks, for which a bond issue of $35,000 has been authorized.

Texas, Pampa—The Southwest Food & Refrigerating Co., has plans under way for an ice-manufacturing and cold storage plant on local site, reported to cost over $100,000, with equipment.

Texas, Taylor—G. L. Rousey, Taylor, and associates plan installation of electric power equipment in a new oil refining plant on local site, estimated to cost about $150,000. A boiler house is planned. It is proposed to organize a company to carry out the project. E. L. Chapman is interested in the enterprise.

Texas, Texon—The Big Lake Oil Co., plans installation of motors, air compressors and other mechanical equipment in proposed new local gasoline refining plant to cost over $200,000.

Utah, Heber—Bonds have been voted and plans are under way for a municipal plant for the town of Heber. Mr. Harry Bletzacker, Magna, Utah, is Consulting Engineer.

W. Va., Clarksburg—The Weirton Steel Co., Weirton, W. Va., is said to be planning rebuilding of boiler plant at its tin plate mill at Clarksburg, recently destroyed by fire. An official estimate of loss has not been made.

Wis., North Milwaukee—The Lakeside Bridge & Steel Co., plans installation of electric power equipment in connection with an expansion and betterment program, reported to cost over $350,000.